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BUTTE URBAN TRANSPORTATION STUDY

TECH - PLAN

REPORT NO. 2

1970
TRAFFIC ASSIGNMENT, TRIP GENERATION, GRAVITY MODEL CALIBRATION

MAY,
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BUTTE
URBAN TRANSPORTATION STUDY
TECH PLAN REPORT NUMBER 2

1970
TRAFFIC ASSIGNMENT,
TRIP GENERATION,
GRAVITY MODEL CALIBRATION

Prepared by

CLETE DAILY AND ASSOCIATES

for

MONTANA DEPARTMENT OF HIGHWAYS
PLANNING AND RESEARCH BUREAU
and
TRANSPORTATION TECHNICAL ADVISORY COMMITTEE

in cooperation with

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

BUT: 610.4

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Federal Highway Administration.

Technical Advisory Committee
Butte Urban Transportation Study
Butte, Montana

Gentlemen:

Enclosed herewith is Tech Plan Report Number 2 covering the 1970 traffic assignment, regression analyses for development of trip generation equations, and calibration of the gravity model. This report is the second in a series of three technical reports published to document in detail the specific work activities of the transportation study.

Comments on draft copies of this report were solicited from the Technical Advisory Committee, the Montana Department of Highways, and the Federal Highway Administration. Approvals of the draft were received prior to printing of the enclosed report.

Our appreciation is extended to each of the aforementioned agencies for their assistance in preparation of this report.

Respectfully submitted,

CLETE DAILY AND ASSOCIATES

Clete Daily

Clete Daily, P.E.

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CHAPTER I

INTRODUCTION

INTRODUCTION

The purpose of this report is to document in detail the methods used in preparation of the 1970 transportation network and to document the methods used to develop the 1970 transportation planning models. Three models were calibrated for use in the Butte Urban Transportation Study. They include the traffic assignment model, the trip generation equations (i.e. model), and the gravity model. Each of these models utilized the 1970 trip file for calibration. The development of that trip file was described in Tech-Plan Report No. 1, entitled, "Travel Surveys", published in September, 1972.

The development and adoption of a transportation plan is the first step in the continuing, transportation planning process. Following publication of the transportation plan by Clete Daily and Associates, other reports may be prepared by the Montana Department of Highways or other agencies to reflect changes in employment and population trends. To document in detail the work activities related to development of the transportation plan, three Tech-Plan Reports will be published. The work to be covered in each Tech-Plan Report is as follows:

Tech-Plan Report 1: Travel Surveys

- Methods and Procedures used in Conducting the Travel Surveys
- Travel Survey Edits and Expansion
- 1970 Population and Employment
- Accuracy Checks

Tech-Plan Report 2: 1970 Models - Traffic Assignment, Trip Generation, Gravity Model Calibration

- For outline, see TABLE OF CONTENTS of this report

Tech-Plan Report 3: 1990 - Land Use Distribution, Trip Generation, Traffic Assignment to E+C

- Forecasting Procedures
- 1990 Land Use Distributions
- 1990 Productions and Attractions
- E+C Network
- Traffic Assignment of 1990 Trips to the E+C Network

Specific work elements of this report are covered in detail in Chapters II through VII.

Chapter II lists detailed definitions for the technical terms which are used throughout this and subsequent reports. Terms that were defined in the first Tech-Plan Report are used in this report without explanation.

Chapter III outlines the procedures used in preparation of the 1970 transportation network. A number of decisions were necessary to initiate the Study, and to define the existing major street network. These decisions are discussed. The methods used for coding, editing, and building the 1970 historical record follow closely the guidelines set forth in the Federal Highway Administration's Urban Transportation Planning manual, and are described herein.

Chapter IV covers calibration of the 1970 traffic assignment model. The 1970 trip file, obtained from the travel surveys, was assigned to the

base year historical record. The travel on each link was compared to the actual ground count. Some links showed volumes lower than actual counts while other links were too high. Link travel speeds were adjusted until the assigned trips closely approximated the 1970 ground counts.

Chapter V describes the procedures used to obtain the zonal totals for 1970 population, employment, dwelling units, and other social-economic variables.

Chapter VI discusses the analyses used in the development of the trip generation equations. The final equations are presented along with the results of numerous statistical tests that were carried out to verify the validity of the equations.

Chapter VII covers calibration of the Gravity Model for each of six (6) trip purposes. Calibration began by using friction factors derived from the Helena Urban Transportation Study. 1970 productions and attractions were distributed by the Gravity Model and the results were compared with 1970 travel data. The friction factors were adjusted until the trip length distributions compared within ± 3%.

Prior to proceeding with the development of a traffic assignment model, it was necessary to establish detailed guidelines which the Consultant would follow. Alternatives that were considered included:

- spiderweb network vs. traditional network
- directional vs. non-directional loading
- all or nothing loading vs. capacity restraint

- peak hour vs. average daily traffic loading
- network trees vs. network vines

The difference between the traditional and the spiderweb networks lies with the degree of detail that is permitted for the coded system. Use of the traditional network permits the use of considerable detail; individual streets and highways are coded as network links and when the traffic assignment is made, trips are loaded directly to these links. In contrast, the spiderweb network consists only of zone (or district) centroids and direct links between them. The details of the street system are not accounted for. Since the goals of the transportation study required knowledge about future traffic or specific routes, the traditional network was chosen.

To complement the decision to use the traditional network, directional routing was used. This permitted the analysis of traffic volumes by direction.

Traffic volumes for 1972 were examined on a number of roadways. They were compared with capacities. No deficiencies were found. Hence, Capacity Restraint techniques were not considered necessary.

Traffic assignments can be made for any desired time period. Peak hour assignments are often made to examine the most critical period for roadway usage. Since the Butte Urban Transportation Study is intended primarily for long range planning and hourly details would not be required, 24 hours traffic assignments were made.

The Consultant's contract called for traffic assignments to five (5) different networks. They included a series of assignments of base year travel to the 1970 network for calibration, assignment of 1990 trips to the existing plus committed network, and the assignment of 1990 trips to three (3) alternate future test systems.

A network tree records the routings so that there is only one entrance link to a node. A vine records the routings such that all four links connected to a node may be traversed if necessary to insure the minimum path. A vine is more accurate than a tree, but more computer time is required for their computation. Because the Butte network is relatively small, the additional time required for vines was not considered excessive. Hence, vines were used.

CHAPTER II

DEFINITIONS

DEFINITIONS

Tech-Plan Report 1, "Travel Surveys" contained a glossary of terms common to that report and to the Butte Urban Transportation Study. Those terms are used without explanation in this report. The reader is referred to "Travel Surveys" for their particular usage in this study.

Terms used in this report are divided into two separate categories. A "General" section includes a glossary of terms common to this report and to the study. The statistical definitions are combined for easy reference while reading Chapters VI and VII.

GENERAL TERMS

Attraction - See Production.

Base Year Highway Network - See Network Description.

Capacity - The maximum number of vehicles which has a reasonable expection of passing over a given section of a lane or a roadway in one direction (or in both directions for a two-lane or a three-lane highway) during a given time period under prevailing roadway and traffic conditions. It is the maximum rate of flow that has a reasonable expection of occurring. If a time modifier is not specified, capacity is an hourly volume. In expressing capacity, the prevailing roadway and traffic conditions must be stated. For further details, refer to the Highway Research Board's Special Report 87, entitled, "Highway Capacity Manual, 1965.

Capacity Restraint - The process of comparing the assigned volume on a link with the vehicular capacity at some chosen level of service (practical capacity), and then adjusting the link travel times until a realistic balance between the assigned volumes and the practical capacity is achieved. Capacity Restraint is an iterative procedure.

Existing plus Committed (E+C) Highway Network - See Network Description.

Employee (EMPLOY) - Refers to the number of people living in a dwelling unit, zone, or district that belong to the labor force.

Employment (EMPLMT) - Refers to the number of people working in a building, zone, or district.

Gravity Model - A mathematical model providing trip distribution. It is based upon the hypothesis that the trips produced at an origin and attracted to a destination are directly proportional to the total trip production at the origin, the total trip attraction at the destination, a calibrating travel time factor, and possibly a socio-economic factor. The socio-economic factor was not used in this study.

Historical Record (HR) - A binary record data set prepared by the computer. The data set includes all information from the network description, but cannot be read directly. Computer program PRINTHR prepares a printed report detailing link information contained in the HR.

Interzonal Traveltime - The total traveltime between zones consisting of the terminal times at each end of the trip plus the driving time.

Interzonal Trip - A trip between two different zones.

Intrazonal Traveltime - The traveltime for a trip originating and ending in the same zone, including the terminal time at each end of the trip.

Intrazonal Trip - A trip with both its origin and destination in the same zone.

Level of Service - A term denoting a combination of operating conditions that may occur on a given lane or roadway when it is accomodating various traffic volumes. A given roadway is capable of providing a wide range of levels of service because the levels are functions of traffic volume, composition of traffic, and of speeds attained.

Link - A section of the highway network between two modes.

Loading - Determination of link volumes (i.e. loads) by selecting zone to zone routes of travel and accumulating the individual trip volumes on each link traversed.

Minimum Path - The travel route between two points which has the least accumulation of travel time.

Network Description - A record describing a computer model of the major street system. Terms used to describe the network include centroids,

nodes, links, leg numbers, turn penalities, link distances, link travel speeds, and other operational characteristics. Three (3) types of networks were used for the Butte Urban Transportation Study.

- 1970 System - A network that described the street system at the time of the travel surveys, i.e. 1970.
- Existing Plus Committed System - A network that reflected any changes between 1970 and 1972, and those improvements that are definitely committed to construction.
- 1990 System - A network illustrating the highway system in the forecast year (1990).

Node - A numbered point representing an intersection of two or more links of the model street network.

Peak Hour - The one-hour period during the day when the maximum amount of travel occurs.

Production, Attraction - Home-based trips consider the place of residence as the production zone (whether it is the zone of origin or destination); the non-residential end of the trip is the attraction zone. Non-home based trips are produced by the zone of origin and attracted by the zone of destination.

Skimmed Trees - A series of binary records containing the travel times between each pair of zones.

Special Zone - A zone having a unique characteristic compared to surrounding zones.

Terminal Time - The time required to unpark or to park a vehicle and the additional walking time required to begin or complete a trip.

Traffic Assignment - Determination of a route of travel and allocation of zone-to-zone trips to that route.

Traveltime - The time required to traverse a link in the street network. Traveltimes were determined by the floating vehicle method and was the average of 4 runs - one during the AM peak, the noon peak, the PM peak and one in an off-peak period.

Trip Generation Equation (or) Regression Equation - A mathematical equation used for estimating a dependent variable from one or more independent variables. The equations used in this study were obtained using step-wise multiple regression..

Vine - A listing of nodes tracing the shortest route from a given zone to all other zones in the highway network. Each link connecting a node is examined for its traveltime to insure that the absolute minimum time path is determined.

STATISTICAL TERMS

Regression equations were developed in order to estimate the value of a dependent variable given one (1) or more independent variables. A number of statistical methods were used to measure the degree of correlation between variables, measure the expected error resulting from estimation, and to measure the significance of the coefficients of the independent variables.

Total variation resulting from estimation is referred to as the Total Sum of Squares, TSS. It represents the amount of error obtained when the mean value is used as an estimate of the dependent variable. The Total Sum of Squares can be divided into the Residual Sum of Squares, Res SS (or unexplained varjation), and the Regression Sum of Squares, Reg SS (or explained variation). If every observation fell along the regression line, there would be no unexplained variation; hence, it is desirable to minimize the Res SS. Then the explained variation will be a larger percent of the total variation and correlation will be greater.

Chi-Square, χ^2 - The sum of the square of the differences (between an observed or expected value and a calculated value) divided by the expected value.

$$\chi^2 = \sum_{i=1}^{N} \frac{(\text{Expected Value - Calculated Value})^2}{\text{Expected Value}}$$

In this report, the Chi-Squared factor was used for calibration of the Gravity Models. The trip distribution from the O-D survey was considered to be the expected values, while the calculated values resulted from the Gravity Model. These distributions were compared using a 98% level of confidence.

Coefficient of Simple Determination, r^2 - The ratio of the Regression SS, or explained variation, to the total variation.

$$r^2 - \frac{\text{Res SS}}{\text{Total SS}}$$

r^2 varies between 0 and 1. For $r^2 = 0$, no relationship or correlation exists between the dependent and independent variables. When

$r^2 = 1$, the goodness of fit is a maximum, and all estimated values fall on the regression line. r^2 is used when only one independent variable is involved.

Correlation Coefficient, r - The square root of the coefficient of simple determination, r^2. It is a measure of the degree of association between any two variables. The simple correlation coefficient, as it is often referred to, ranges from -1 to +1. The sign indicates the slope of the regression line and the degree of correlation is maximum at a value of one.

Coefficient of Multiple Determination, R^2 - The ratio of the Regression Sum of Squares, or explained variation, to the total variation.

$$R^2 = \frac{\text{Res SS}}{\text{Total SS}}$$

R^2 ranges between 0 and 1, and is analogous to the coefficient of simple determination; however, R^2 is used when more than two variables are involved.

Multiple Correlation Coefficient, R - The square root of the coefficient of multiple determination, R^2. It is a measure of the degree of correlation between a dependent variable and two or more independent variables. R varies between -1 and +1. The sign indicates the slope of the regression line and the degree of correlation is maximum at a value of one.

F Ratio - The F ratio of two independent, random samples is the variance of the first divided by the variance of the second.

$$F = \frac{\sigma_1}{\sigma_2}$$

In this text, the F ratio is used as a test between the dependent variable and each of the independent variables being used for possible entry into a regression equation. In general, the higher the value of F, the better the independent variable is for predicting the dependent variable.

Mean (Arithmetic), $\bar{x}$ - The average of a set of N numbers.

$$\bar{x} = \frac{X_1 + X_2 + X_3 + \cdots\cdots + X_N}{N}$$

Root Mean Square Error, R.M.S. - The square root of the sum of the differneces (between an observed or expected value and a calculated value) divided by the number of observation periods.

$$\text{R.M.S. Error} = \sqrt{\frac{\sum_{i=1}^{N} (\text{Expected Value - Calculated Value}}{N}}$$

Note that the R.M.S. error is similiar to the standard deviation.

Percent Root Mean Square Error, % R.M.S. - The Root Mean Square Error expressed as a percent of the mean value.

$$\text{\% R.M.S.} = \frac{\text{R.M.S.}}{\text{Mean of Observations}} \times 100$$

Standard Error of Estimate, Sy.x - A measure of the dispersion of the observed values about the regression line.

$$\text{Sy.x} = \sqrt{\frac{\text{Res SS}}{\text{degrees of freedom}}} = \sqrt{\frac{\text{Unexplained Variation}}{\text{degrees of freedom}}}$$

This measure is analogous to the standard deviation of a set of data points about the mean value. 68.3% of the observations can be expected to fall within plus or minus one standard error of estimates from the regression line.

Percent (%) Standard Error - A ratio of the standard Error of Estimate to the mean of the observed values of the dependent variables.

$$\% \text{ Standard Error} = \frac{\text{Standard Error of Estimate, Sy.x}}{\text{Mean, } \overline{Y}}$$

It is a measure of the spread of the observed values about the regression line. As the percent increases, the greater is the spread (or bandwidth) about the regression line.

Standard Deviation, s^2 - The root mean square of the deviations from the mean.

$$s^2 = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \overline{X})^2}{N}}$$

N is replaced with N-1 to obtain the unbiased standard deviation.

It is a measure of the absolute variation, and is used to indicate the actual amount of variation in a set of data. Also, see Root Mean Square Error.

Standard Error of Regression Coefficient, Sx - The probable range in which the actual slope of the regression line is expected to be. This measure is analogous to the standard deviation of a set of data points about a mean value. 68.3% of the time the estimated regression coefficient will fall within plus or minus one standard error.

Variance, - The square of the standard deviation.

CHAPTER III

PREPARATION OF THE 1970 HIGHWAY NETWORK

PREPARATION OF THE 1970 HIGHWAY NETWORK

The preparation of the 1970 Highway Network began with the delination and adoption of the test network and the development of a network coding system.

SELECTION OF 1970 HIGHWAY NETWORK

The initial 1970 network was delineated by the 1968 Highway Functional Classification System. This system was adjusted during the loading of 1970 origin-destination trip ends, to achieve loadings that closely matched the actual ground counts. The adjustments consisted of addition of some local streets to provide better trip distribution. A final 1970 network was adopted by the Technical Advisory Committee.

CODING THE 1970 HIGHWAY NETWORK

Following the adoption of the 1970 major street network, a zone centroid and network node numbering system was devised.

Analysis zone boundaries were established by the Montana Department of Highways prior to the origin-destination surveys which were made in the Fall of 1970. The study area was divided into 115 traffic zones with eight external stations. Wherever feasible, the zone boundaries are coincident with enumeration district boundaries established by the U. S. Bureau of Census. This allows a comparison of travel survey data with data collected in the 1970 Census.

The centroid numbers begin with one (1) and continue consecutively for all zones to number 115. The Central Business District (C.B.D.) contains all zones from one (1) to 23, and the remaining zones in the study area utilize numbers 24 through 115. The eight external stations were numbered 116 through 123. These numbers are illustrated in Figure A-3 in the Appendix.

Node numbering began in the C.B.D. with number 200 and proceeded consecutively throughout the entire network to number 691. Figure III-1 illustrates the base year network in its final form. All centroid and node numbers are shown.

Figure III-3 is a copy of the Link-Node coding sheet provided by the Montana Department of Highways. This form was used for coding the network with only one revision. Columns 75 through 78 call for a route number; this was replaced by a sequence number beginning with one (1). The purpose of this was to permit a card sort into the same order as the original coding sheets should their order become scrambled. The card sequence number proved useful during editing of the coded network.

Each column on the Link-Node coding sheet will be discussed below. The purpose is to identify each type of information that is contained in the historical record and to point out the methods of coding.

Column 1: Not used.

Column 2-6: and 8-12: Node A and Node B

In the case of two-way links, the order of the node numbers

BUTTE URBAN TRANSPORTATION STUDY

1970 HIGHWAY NETWORK

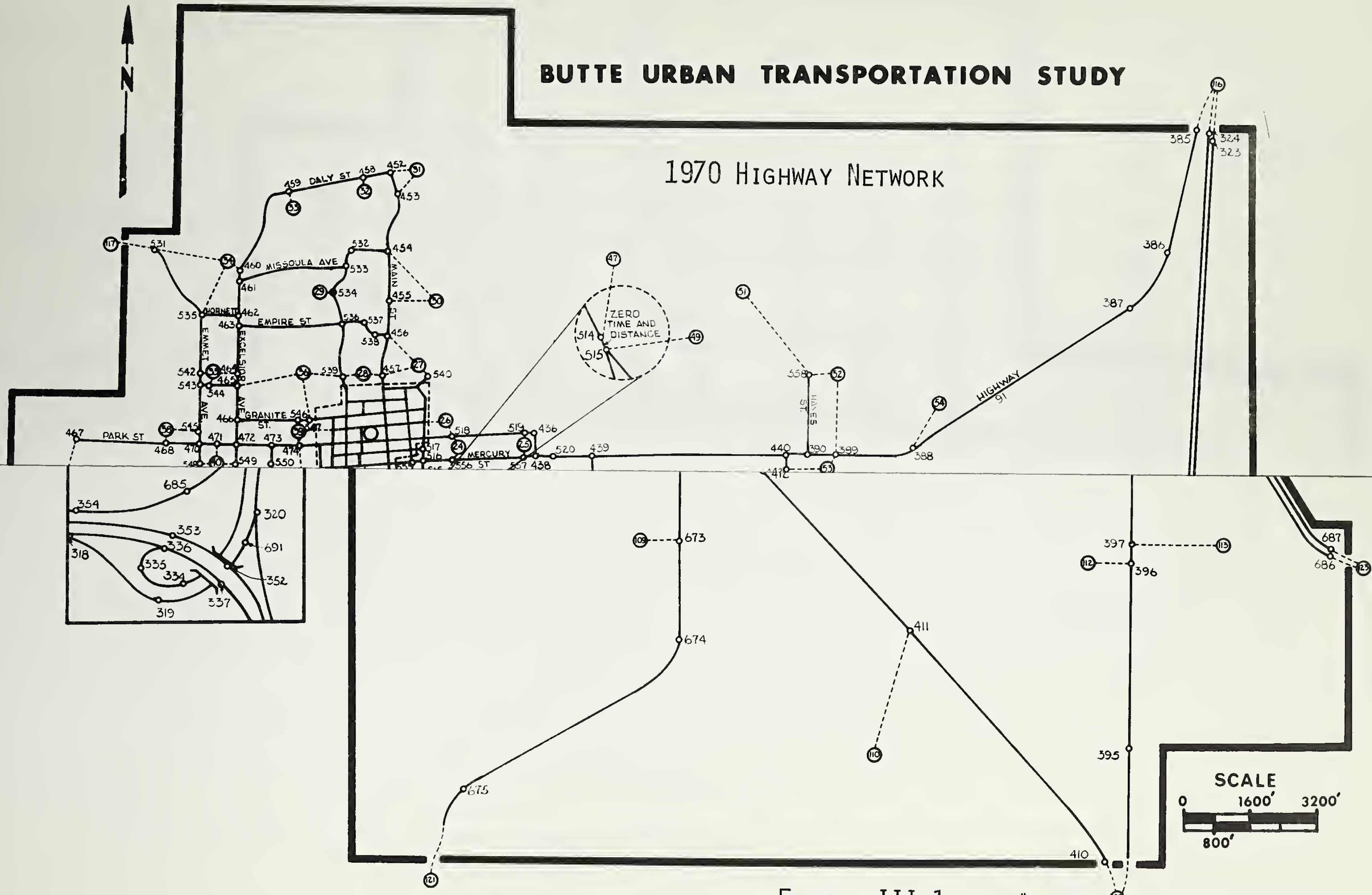


FIGURE III-1

CLETE DAILY AND ASSOCIATES
Helena, Montana

BUTTE URBAN TRANSPORTATION STUDY

1970 HIGHWAY NETWORK

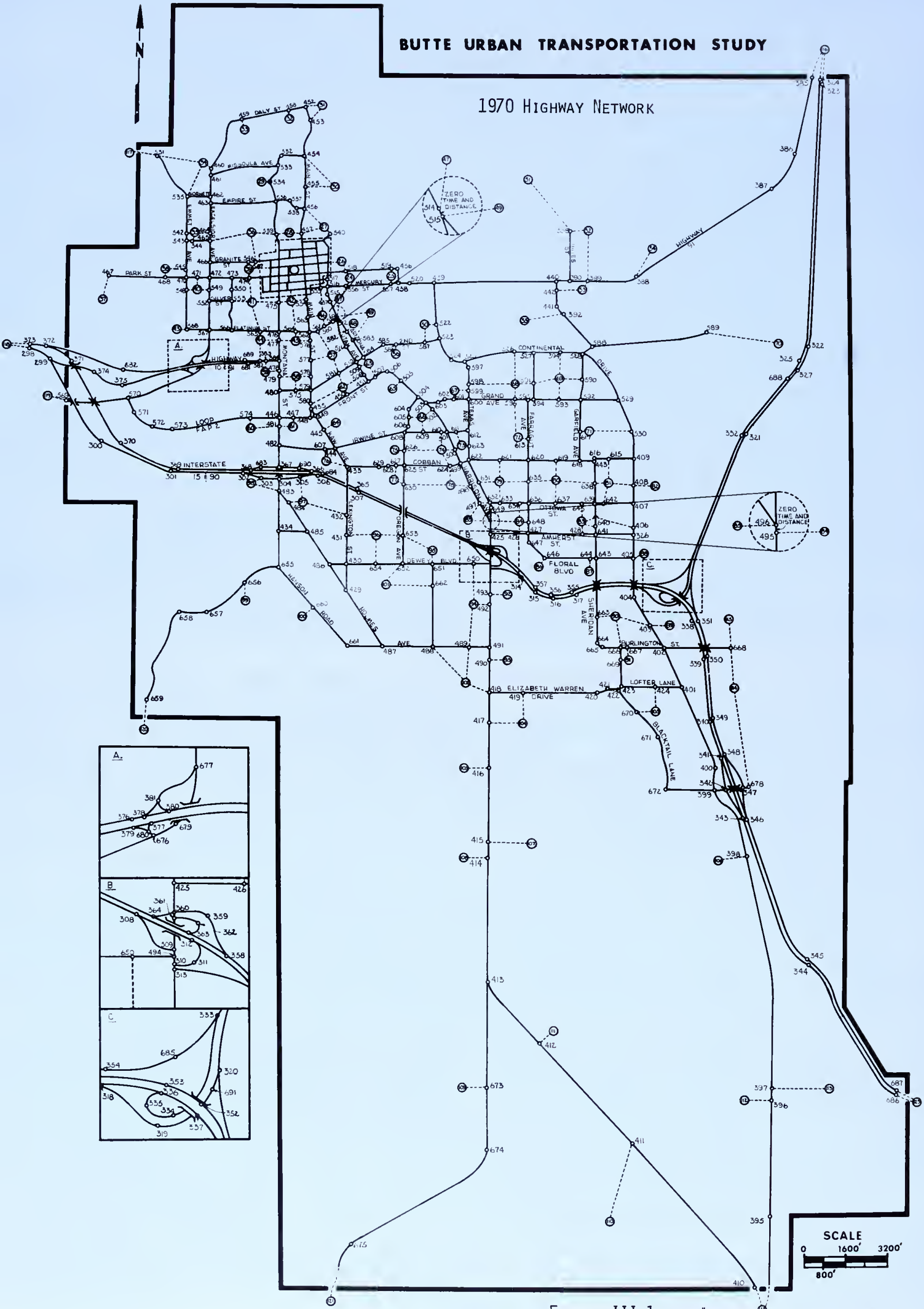
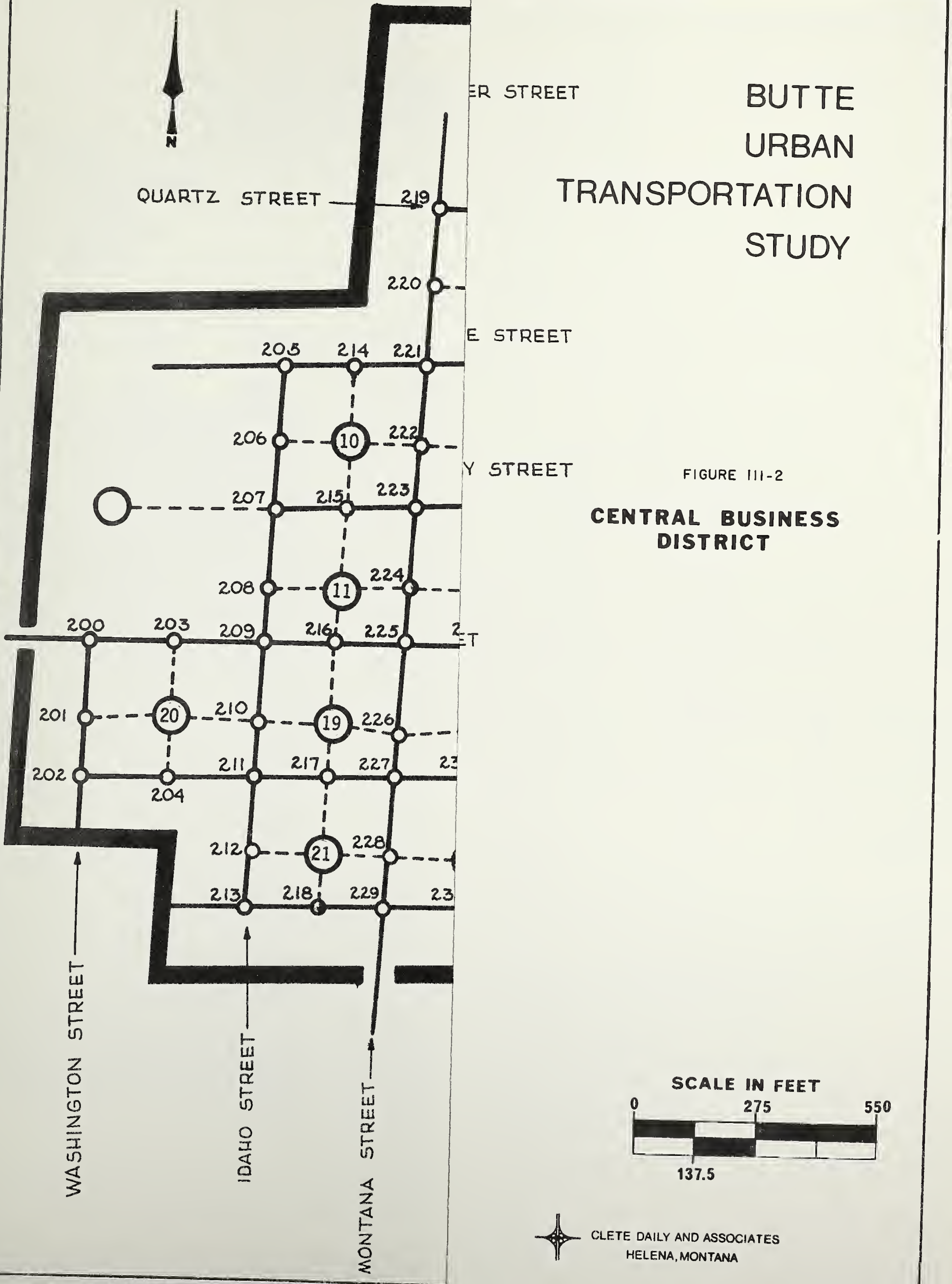


FIGURE III-1

CLETE DAILY AND ASSOCIATES
Helena, Montana



BUTTE URBAN TRANSPORTATION STUDY

FIGURE III-2

CENTRAL BUSINESS DISTRICT

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

BUTTE URBAN TRANSPORTATION STUDY

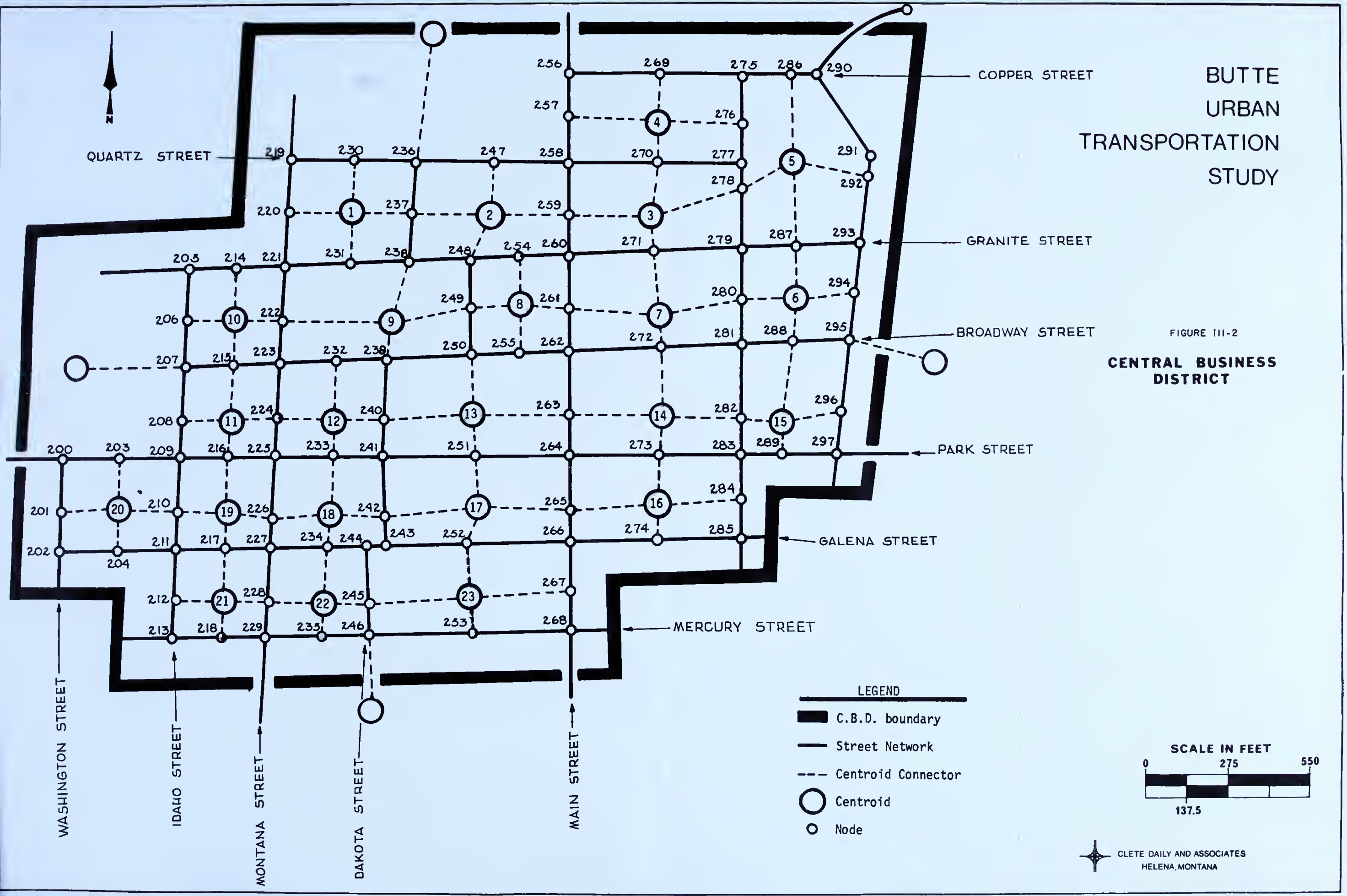


FIGURE III-2

CENTRAL BUSINESS DISTRICT

URBAN
TRANSPORTATION
PLANNING
SUBSECTION
IBM 360

	LINK													
	NODE A					A-NODE LEG. NO.	NODE B					B-NODE LEG. NO.	DISTA	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

FIGURE III-3

URBAN
TRANSPORTATION
PLANNING
SUBSECTION
IBM 360

MONTANA HIGHWAY COMMISSION
PLANNING SURVEY SECTION
STREET NETWORK
LINK—NODE CODING SHEET

CITY ____________ PAGE ______
NETWORK BASE YEAR ____________
OR
NETWORK FORCAST YEAR ____________
CODER'S INITIALS ____________
DATE CODED ____________

	LINK					A TO B									B TO A																		
	NODE A	A-NODE LEG. NO.	NODE B	B-NODE LEG. NO.	DISTANCE	"T" OR "S"	TIME OR SPEED	TURN PEN-ALTY CODES AT NODE B	HOURLY CAPACITY	CON-VERS'N FACTOR VPH/ADT .000	DIRECTIONAL COUNT	STREET WIDTH	PARKING		"T" OR "S"	TIME OR SPEED	TURN PEN-ALTY CODES AT NODE A	HOURLY CAPACITY	CON-VERS'N FACTOR VPH/ADT .000	DIRECTIONAL COUNT	STREET WIDTH	PARKING		ADM. CLASS.	FUNCT'L CLASS	TYPE FACILITY	SURFACE TYPE	TYPE AREA	LAND USE	LINK LOCATION	CARD SEQUENCE NO.	CONDITION	
1	2 3 4 5 6	7	8 9 10 11 12	13	14 15 16 17	18	19 20 21	22 23 24	25 26 27 28	29 30 31	32 33 34 35 36	37 38	39	40	41	42 43 44	45 46 47	48 49 50 51	52 53 54	55 56 57 58 59	60 61	62	63	64	65	66	67	68	69 70	71 72 73 74	75 76 77 78	79	80

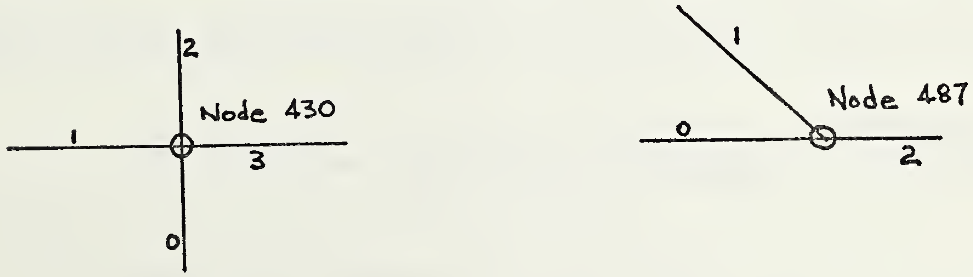
was not restricted. That is, either end of a link could be referred to as Node A, as long as subsequent coding on that card was consistent.. One-way links, such as interstate routes, required that the A node to B node direction correspond to the direction of traffic flow. Columns 41 through 62 (i.e. B node to A node) were left blank. Right justification was used for coding the node numbers.

Columns 7 and 13: A Node and B Node Leg Numbers

Each link entering a node or centroid was assigned a leg number. The number zero (0) was assigned to the south leg. If there was no south leg, then the west leg became number zero (0). Following the first leg, the remaining legs were numbered consecutively in a clockwise direction. Examples are given below:

FIGURE III-4

NETWORK LEG NUMBERS



Columns 14-17: Distance

The distance from A node to B node was coded to the nearest hundredth of a mile. It was right justified.

Columns 18-40: Contain directional data for Node A to Node B.

Column 18: "T or S"

Column 18 called for a "T" or "S", depending upon whether

travel time or travel speed, respectively, was coded in columns 19-21. The "S" was coded to represent speeds.

Columns 19-21: Time or Speed

The average daily travel speeds were recorded to the nearest tenth of a mile per hour.

The Montana Department of Highways, in 1970, performed a series of travel time runs over the major street network in each direction of traffic flow and the elapsed time since the beginning of that run were recorded at specified control points. Normally one run per route in each direction was conducted during each of the following periods: morning peak, noon peak, afternoon peak, and off-peak. Since 24-hour traffic assignments were planned, an average traveltime was required. Traffic counts were examined and it was found that the peak hours carried approximately 25% of the total daily traffic. Hence, the following formula was used to compute the average daily traffic traveltime.

$$\text{ADT Traveltime} = \frac{3(\text{off peak traveltime} + 1\ (\text{average peak hour traveltime})}{4}$$

Traveltimes were converted to travel speeds because errors and unreasonable values could be easily determined by inspection. The ADT travelspeeds were coded on the Link-Node coding sheet, but during calibration of base year network, as explained in Chapter IV, these speeds were adjusted so that the assigned volumes would approximate the 1970 ground counts. Hence, the speeds that appear in the final historical record represent the adjusted travel speeds. The original speeds can

be found in the printout of the base year historical record before adjustments. It is the first traffic assignment of base year trips to the 1970 network, and is dated August 14, 1972.

Columns 22-24: Turn Penalty Codes at Node B

Turn Penalty codes were used at both ends of all two-way links. For one-way links they were coded only at Node B. The codes used and the associated delay are as follows:

Code	Type of Movement	Delay (minutes)
0	Straight Through; no penalty	0.0
1	Right Turn	0.1
2	Extremely Bad Right Turn & Easy Left Turn	0.2
3	Left Turn	0.3
4	Extremely Bad Left Turn	0.4
5	Prohibited Movement	---

Columns 25-28: Hourly Capacity

Hourly capacities were not coded.

Columns 29-31: Conversion Factor, VPH/ADT

Conversion factors were not coded.

Columns 32-36: Directional Count

The Montana Department of Highways conducted 24-hour, non-directional traffic counts at a number of locations in the Butte urban area from 1968 to 1972. Peak hour turning movement counts were taken at each signalized intersection in 1971. Screenline and cordonline 24-hour traffic counts were made in 1970. All

counts were analysed by the Consultant and wherever necessary, adjustments to represent 1970 conditions were made. To arrive at the average daily traffic (ADT) for each network link, some averaging and interpolation was necessary. Having obtained the ADT, directional link volumes were approximated as 50% of the ADT. The directional count for node A to node B was coded in columns 32-36. It was right justified.

Directional traffic counts were available for a few locations, such as in the C.B.D. Wherever they existed, a more accurate directional ADT was obtained and coded.

Columns 37-38: Street Width

The street widths were measured between curb faces. If curbs did not exist, the street width was measured from pavement edge to pavement edge. The widths were coded to the nearest foot.

Column 39: Parking

Parking type was coded according to the following four (4) numeric codes:

Parking Type	Numeric Code
Parallel	1
No Parking	2
Angle	3
Parallel Parking on Shoulder	4

For Node A to Node B, the parking code refers to the right side of the roadway.

Column 40: Not used.

Columns 41-63: Contains directional data for node B to node A. For reference to individual columns, the reader is referred to columns 18-40.

Column 64: Administrative Class

The administrative class was not coded.

Column 65: Functional Classification

The 1990 Functional Highway Classification was coded according to the following:

1990 Functional Classification	Code
Freeway	0 or 1
Principal Arterial	2
Minor Arterial	3
Major Collector	4
Minor Collector	5
Centroid Connector	7
Freeway Ramps	8
Local Street	9

Column 66: Type Facility

The 1970 Federal Aid Highway System designation was coded with the following numeric codes:

1970 Federal Aid System	Code
Federal Aid System	
Interstate	0

Primary	1
Secondary	2
Non-Federal Aid System	
Local	4
Other	5
Centroid Connector	7

Column 67: Surface Type was not coded.

Column 68: Type Area

The entire study area was divided into five categories according to land use patterns and guidelines from the Highway Capacity Manual. These areas are shown in Figure III-5. They were subsequently used for service volume calculations. Five codes were used to identify the areas on the Link-Node Cards.

Type Area	Code
Central Business District	3
Fringe	4
Outlying Business District	5
Residential	6
Rural	7

Columns 69-70: Land Use was not coded.

Columns 71-74: Link Location

The study area was divided into twelve (12) districts. They are illustrated in Figure III-6. Each link was assigned a code

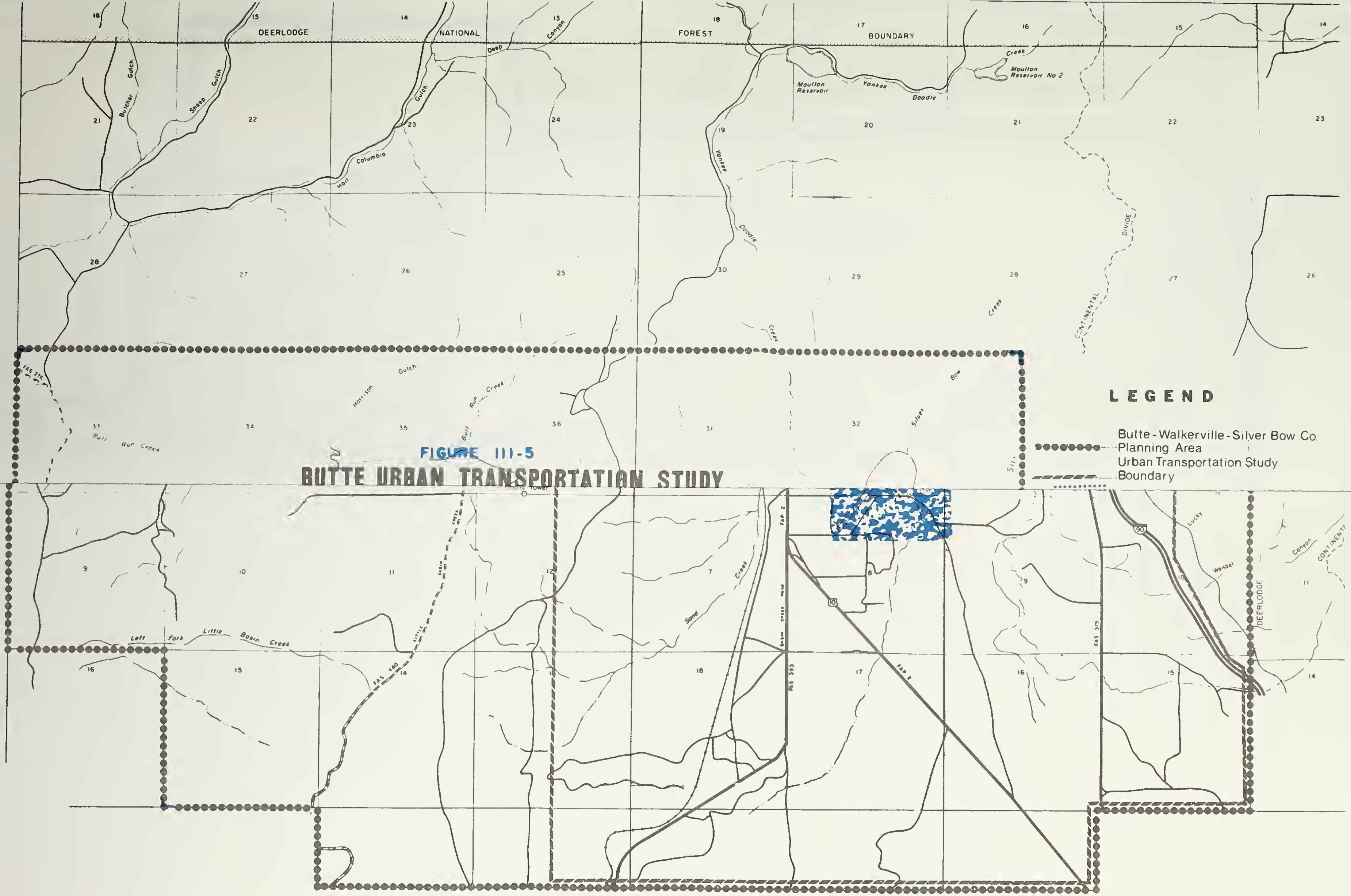


FIGURE III-5

BUTTE URBAN TRANSPORTATION STUDY

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

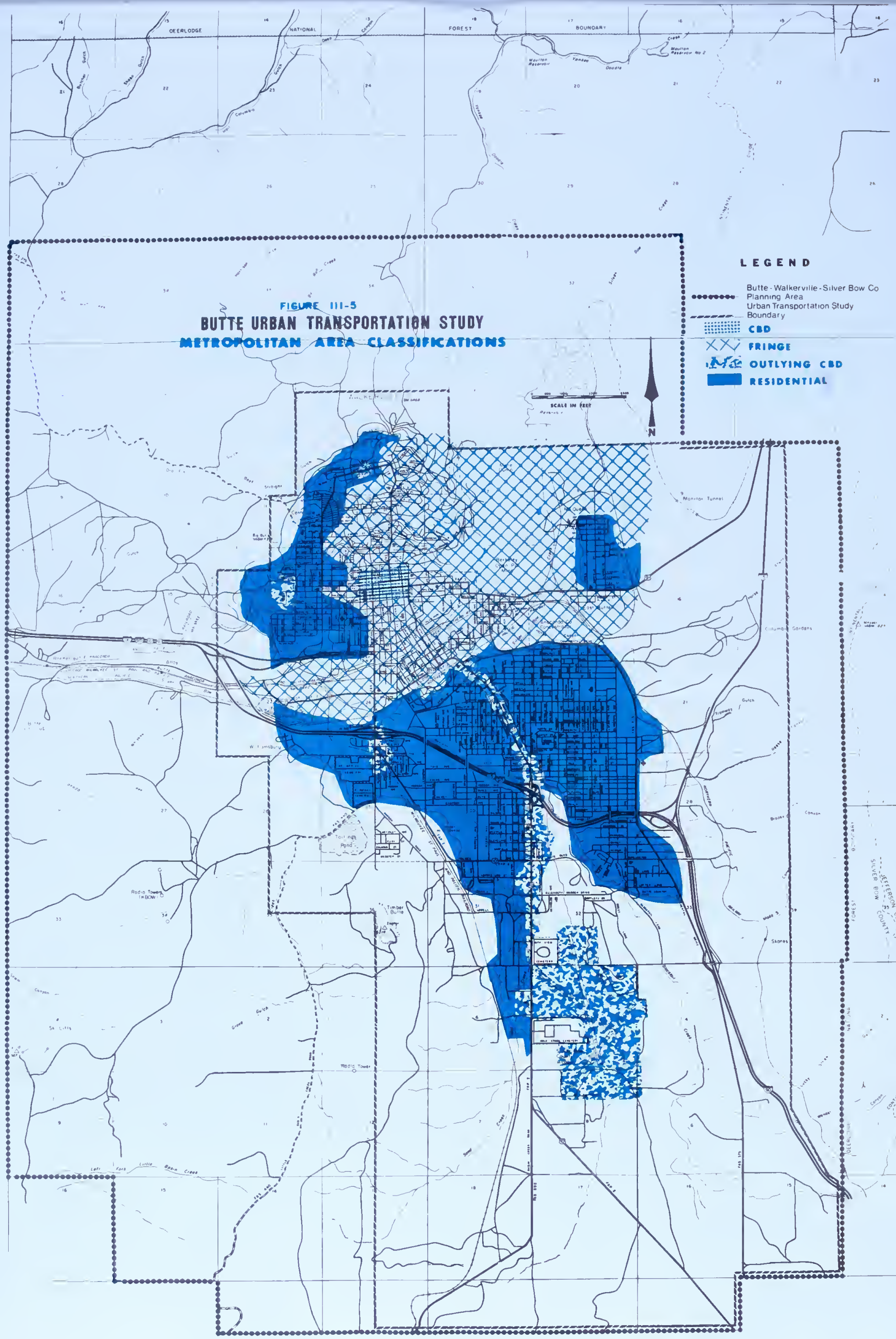


FIGURE III-5
BUTTE URBAN TRANSPORTATION STUDY
METROPOLITAN AREA CLASSIFICATIONS

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

Butte Urban Transportation Study

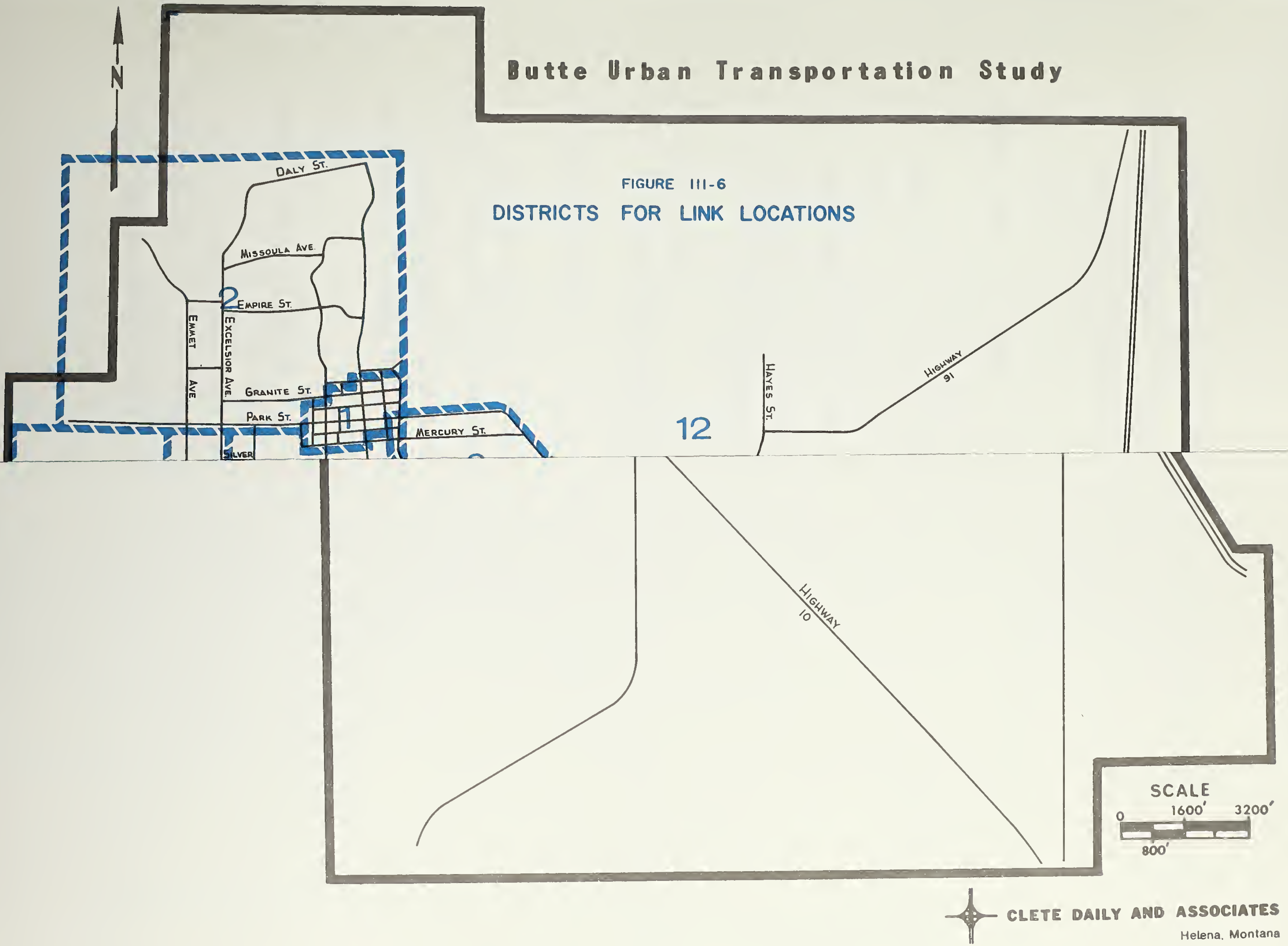


FIGURE III-6

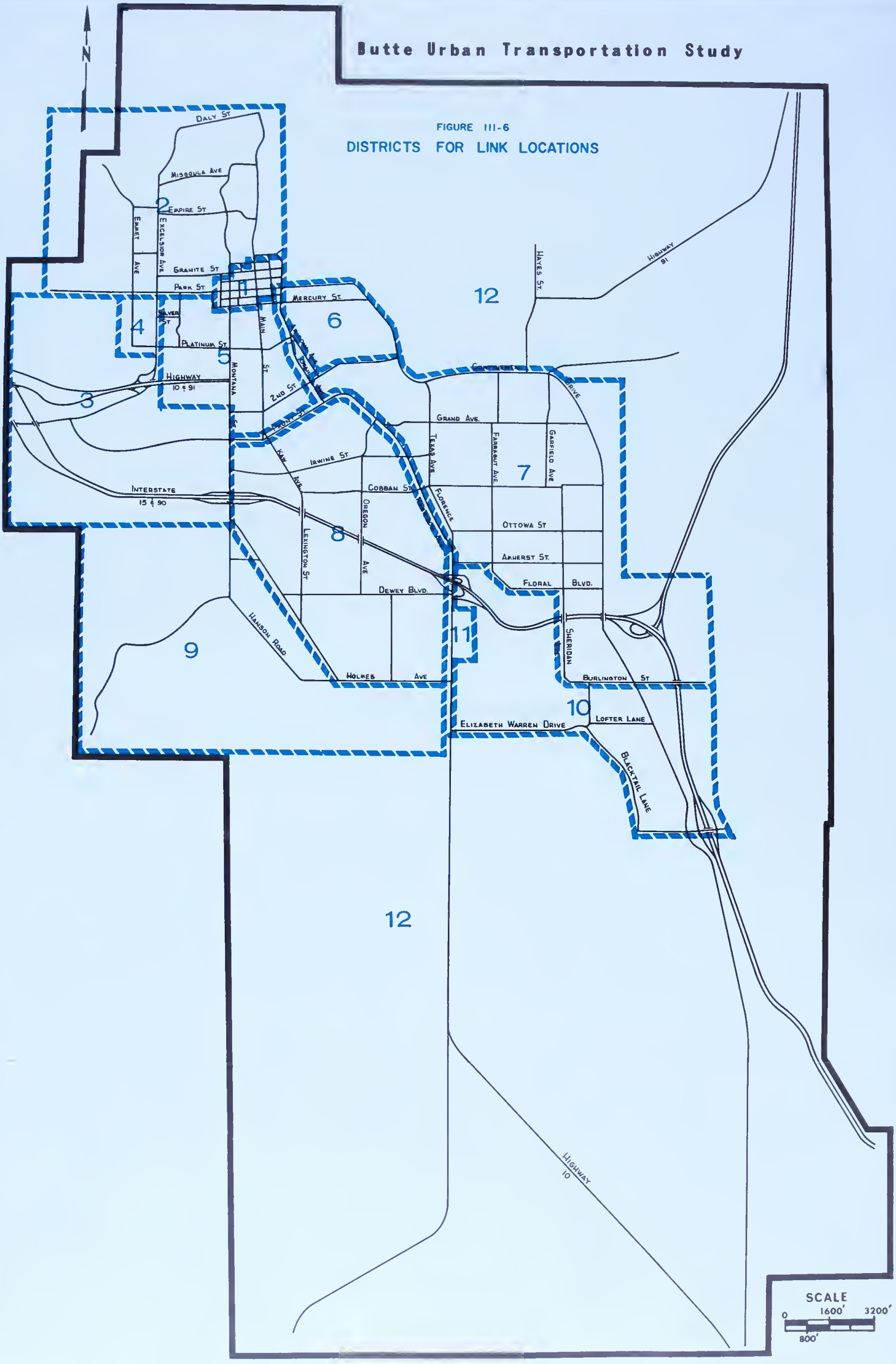
DISTRICTS FOR LINK LOCATIONS

CLETE DAILY AND ASSOCIATES
Helena, Montana

Butte Urban Transportation Study

FIGURE III-6

DISTRICTS FOR LINK LOCATIONS



CLETE DAILY AND ASSOCIATES
Helena Montana

that corresponded to one of these districts. The numbers were right justified. This link location number helped to locate the link during the network editing process and proved to be very useful.

Columns 75-78: Link Number

Following the network coding, but prior to keypunching, each row on the Link-Node Coding Sheet was assigned a sequence number. The assigned number began with one (1) and followed consecutively in the order in which the links were coded. After keypunching, the cards could always be sorted into the same order as the original Link-Node Coding Sheets.

Column 79: Condition:

The pavement condition was not coded.

Column 80: Not used.

When the coding and checking of the Link-Node coding sheets was complete, they were keypunched and verified. Then they were submitted to the BUILDHR computer program, where editing began. The editing and correction of the coded links is described in the last section of this chapter.

CODING NETWORK COORDINATES

A gird was placed over a copy of the base year network. Both horizontal and vertical coordinates were measured and coded for each node and each centroid. These coordinates were keypunched, verified,

and submitted to the CALCOMP computer plot routines. See Figure IV-1 for an illustration of the flow of work activities.

Computer program GESERT was used to insert the network coordinates into the base year historical record. Program GEPREP utilized this updated historical record and prepared the network or paths for plotting. Then the program GEPLOT was used to plot the network system. Single line plots were obtained.

EDITING THE BASE YEAR NETWORK

Before the base year historical record could be used with the BUILDVN program, it had to be thoroughly edited. Three steps were used in the editing process. Each is explained below:

1. The Link-Node cards were submitted to the BUILDHR computer program. The purpose of this program is to read the link cards, edit them, and build the historical record data set. A few coding errors, involving leg numbers, turn penalties, and travel speeds were identified and corrected. Upon running the program the third time, the base year historical record was successfully prepared.
2. The CALCOMP computer plot rountines were used to plot the network. A few missing links were identified. Also, approximately ten (10) coordinates were plotted in the wrong location, indicating inaccurately coded coordinates. These errors were

corrected and the results of the second plot were satisfactory.

3. The historical record data set was submitted to the BUILDVN program. Vines were prepared. The logic of these minimum impedence paths was checked by printing vines for three (3) zone centroids (7, 23, and 101) and three external stations (116, 118, and 123). The path from all other centroids to the specified zone was identified by a sequence of node numbers. These routes were manually traced on a network map. Routings were considered logical except at the interchange of Harrison Avenue and I90-I15. A few turn penalties had been miscoded and caused inaccurate paths. Since these changes were relatively minor, they were corrected after the first base year traffic assignment.

Figure IV-1 illustrates the flow of work activities described above. The base year historical record and the zone-to-zone minimum time paths have been successfully prepared. Meanwhile, as described in Tech-Plan Report 1, entitled, "Travel Surveys", the base year origin-destination (O-D) trip table was prepared. At this point, the LOADVN program was used to assign the O-D trips to the historical record data set. This activity will be dscribed in the next chapter.

CHAPTER IV

TRAFFIC ASSIGNMENT

TO THE

1970 NETWORK

TRAFFIC ASSIGNMENT TO THE 1970 NETWORK

The 1970 origin-destination trip table was assigned to the 1970 major street network. The loadings obtained from this assignement were compared to actual ground counts on the network. The traffic assignment model is calibrated when these volumes match within reasonable limits.

Several adjustments to the network were necessary to calibrate the assignment model. Two types of adjustments were made:

1. Addition or deletion of links in the major street network.
2. Adjustment of travel times on network links.

The first traffic assignment revealed the following discrepancies between the model and actual ground counts on several network links.

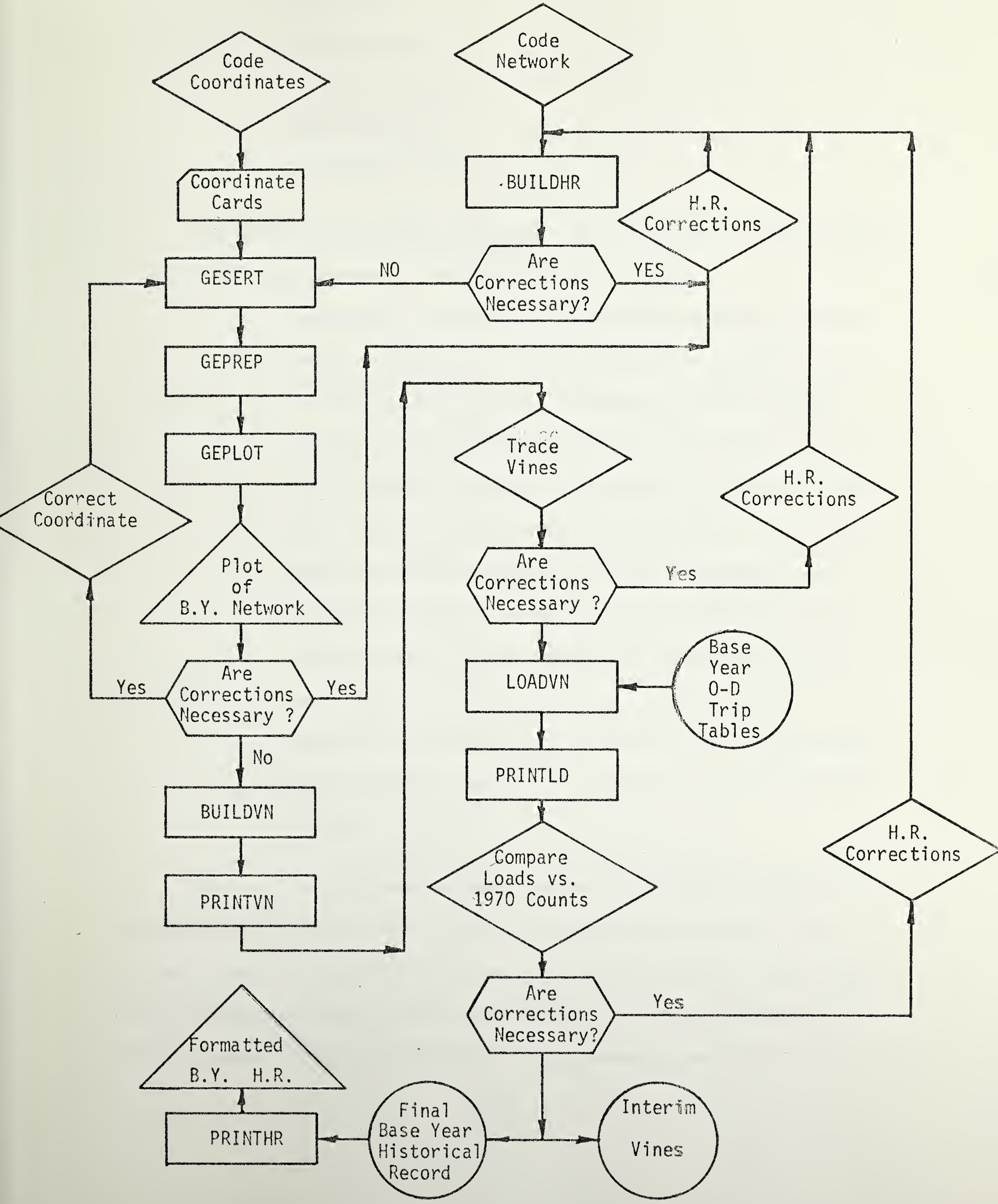
Significant overloads occurred on the following routes:

- I-90 Montana Avenue to Harrison Avenue
- Montana Street north of I-90
- Harrison Avenue south of I-90
- Florence Avenue
- Texas Avenue
- Continental Drive

Significant underloading occurred on the following routes:

- Kaw Avenue and Main Street
- Harrison Avenue north of I-90

FIGURE IV-1
TRAFFIC ASSIGNMENT BASE YEAR



- Rowe Road
- Holmes Avenue
- Lexington Street
- Dewey Boulevard
- Walkerville area

The major travel speed adjustments were made over a series of ten (10) traffic assignments. These adjustments included:

- Reduction of traveltime on I-90 between Montana Avenue and Harrison Avenue. This adjustement diverted traffic to parallel facilities. Although the I-90 route does provide a high speed facility for local traffic along this corridor, it appears that there are factors other than traveltime influencing the actual use of this route. Other studies have shown a similiar phenomenon due to reluctance of local drivers to change from time established routes, lack of familiarity with the relatively new routes.
- Reduction of speeds along the Texas Avenue - Continental Drive corridor resulted in increased volumes on Harrison Avenue.

When a close agreement between the loads and actual counts was obtained for the major streets, small adjustments were made to other minor streets. The last few assignments resulted in minor improvements with loadings on some routes being extremely sensitive to changes in travel speed. After the tenth traffic assignement, the 1970 network

was considered to be calibrated.

The external stations showed reasonable agreement between the loadings and the ground counts. Total trips loaded was 17,564 while the ground count indicated 17,886. The difference was 322 trips or 1.80%. Theoretically, these totals should be identical. The differences at each station were random and is due to rounding of adjustment factors.

Particular attention was given to the seven (7) screenline stations. Each of these stations represented major routes in the study area and offered a good index for determining the degree of calibration. Results of the screenline comparisons are illustrated in Table IV-1.

TABLE IV-1

SCREENLINE COMPARISONS FOR BASE YEAR LOADING

Screenline Station No.	Location	1970 Ground Count	1970 Traffic Assignment	Difference No.	Difference %
1	I90-I15 just west of Montana Street	5,769	6,366	+ 597	+10.3
2	Montana Street north of Front Street @ Burlington Northern R.R. overpass	8,218	9,607	+1389	+16.9
3	Kaw Avenue south of Front Street @ Burlington Northern R.R. tracks	6,564	6,259	- 305	- 4.6
4	Harrison Avenue @ Burlington Northern R.R. overpass	17,086	17,106	+ 20	+ 0.0

Screenline Station No.	Location	1970 Ground Count	1970 Traffic Assignment	Difference No.	Difference %
5	Continental Drive South of Second St. @ Burlington Northern R.R. underpass	6,144	5,027	-1117	-18.2
6.	Stuart Street north of Montgomery Street @ the Burlington Northern R.R.	2,644	3,041	+ 397	+15.0
7	I15 north of I15-I90 junction	923	955	+ 32	+ 3.5
TOTAL		47,348	48,361	+1013	+ 2.1

It is seen that there is some variation between loadings and ground counts at individual screenline stations. Travel speeds were adjusted in an effort to reduce these differences; very small speed changes resulted in significant changes in the volumes of assigned traffic. This resulted in at least one station that would deviate by fifty percent or more. The final loading minimized the amount of variation at each station, and the absolute differences were not considered excessive.

Since adjustments were made to the travel data at the screenline, the total number of vehicles loaded should be equal to the ground count. The difference of 1013 vehicles is due to rounding of the 16 to 24 hour adjustment factor and a few multiple screenline crossings during assignment. These totals indicated a comparison of nearly 98% which was considered sufficiently accurate.

The Walkerville area was examined in detail. It is comprised of zones 29 through 34. This area was found to have twelve (12) percent fewer vehicles per household than the study area as a whole. The number of trips per occupied household average 3.12 compared with 7.88 for the entire study area. There is indication of underreporting of trips during the interview survey, but because the area has many retired residents without vehicles, it was expected to be somewhat lower than other districts. Since the screenline adjustments were based on the entire study area, the number of trips from any specific zone (or group of zones) may be high or low depending upon the trip reporting in that area. The six zones forming Walkerville accounted for 6,434 trips, or 5.7% of the total trips during 1970. It was concluded that individual adjustment of trips was not necessary.

Figure IV-2 is a graphical comparison of 1970 average daily traffic (ADT) and assigned traffic from the travel surveys. Major differences still occurred in the Central Business District. These differences are due to the inability of the model to simulate circulating vehicles searching for parking convenient to the driver's destination. A cordon line was placed around the Central Business District. According to ground counts, there were 48,330 trips to and from the Central Business District. The traffic assignment indicated 45,710 trips, or 5.4 percent low. This difference is attributed to circulating traffic.

Butte Urban Transportation Study

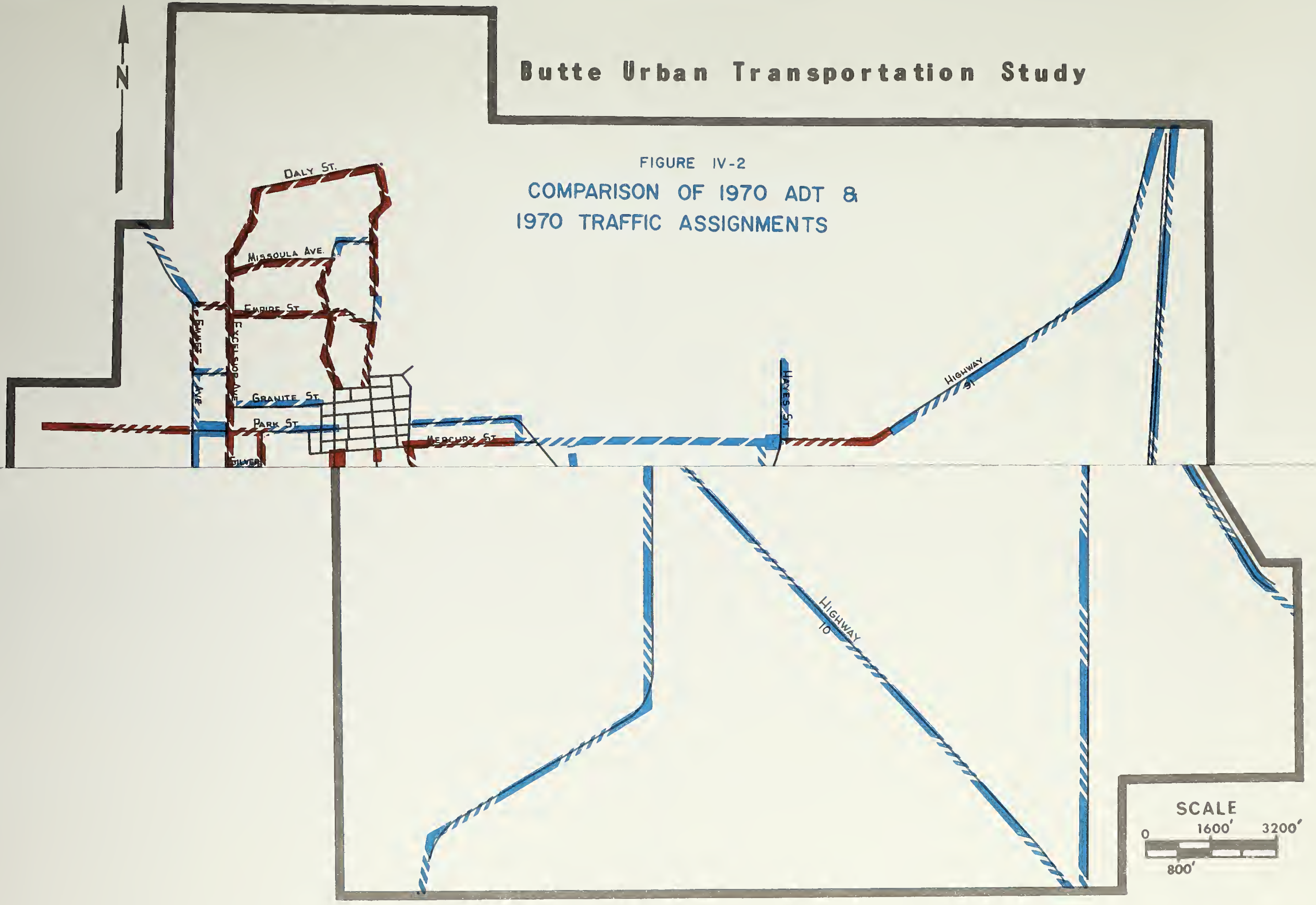
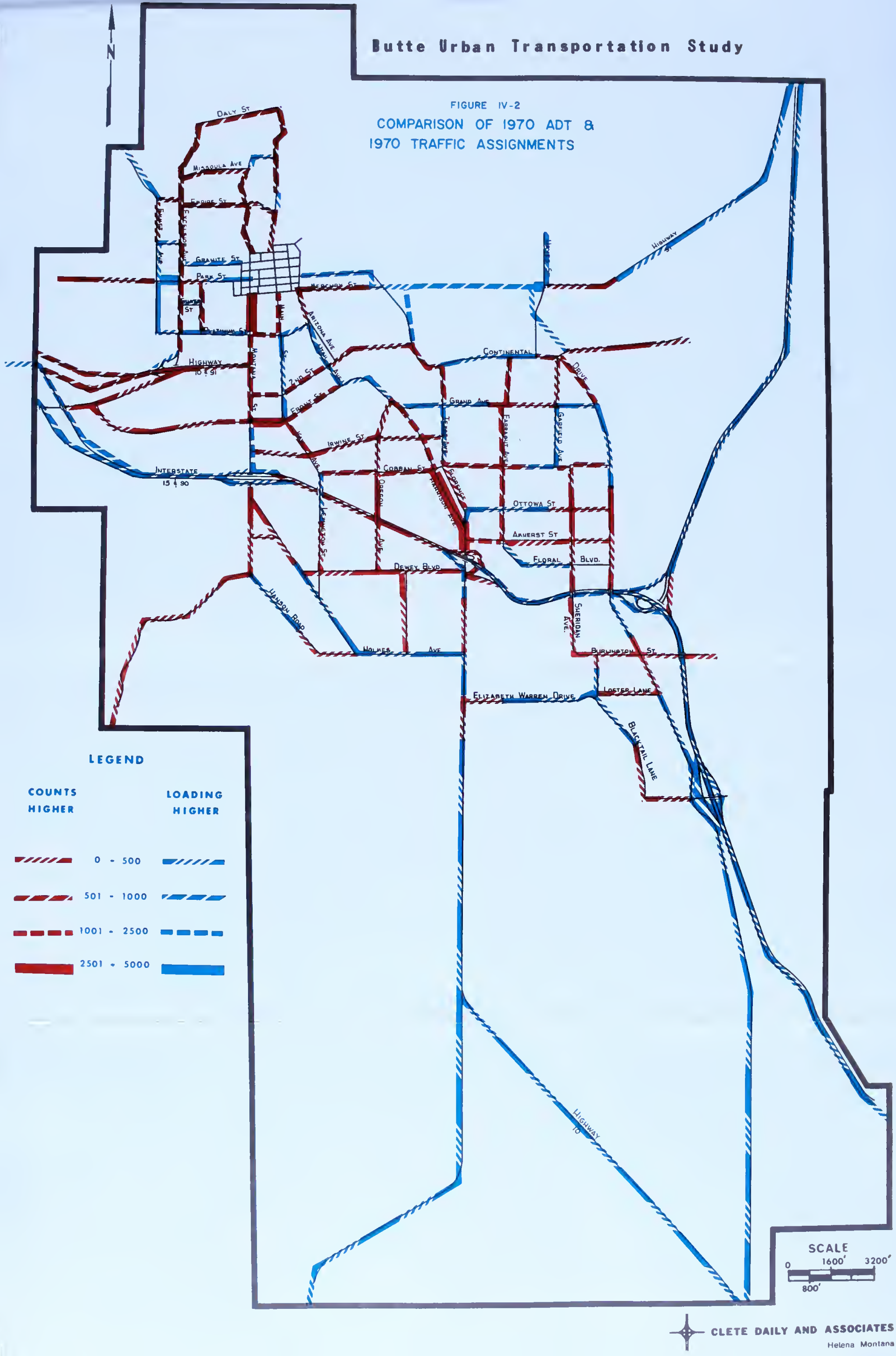


FIGURE IV-2

COMPARISON OF 1970 ADT &
1970 TRAFFIC ASSIGNMENTS

CLETE DAILY AND ASSOCIATES
Helena, Montana



Butte Urban Transportation Study

FIGURE IV-2
COMPARISON OF 1970 ADT & 1970 TRAFFIC ASSIGNMENTS

CLETE DAILY AND ASSOCIATES
Helena Montana

CHAPTER V

BASE YEAR TRIP GENERATION VARIABLES

BASE YEAR TRIP

GENERATION VARIABLES

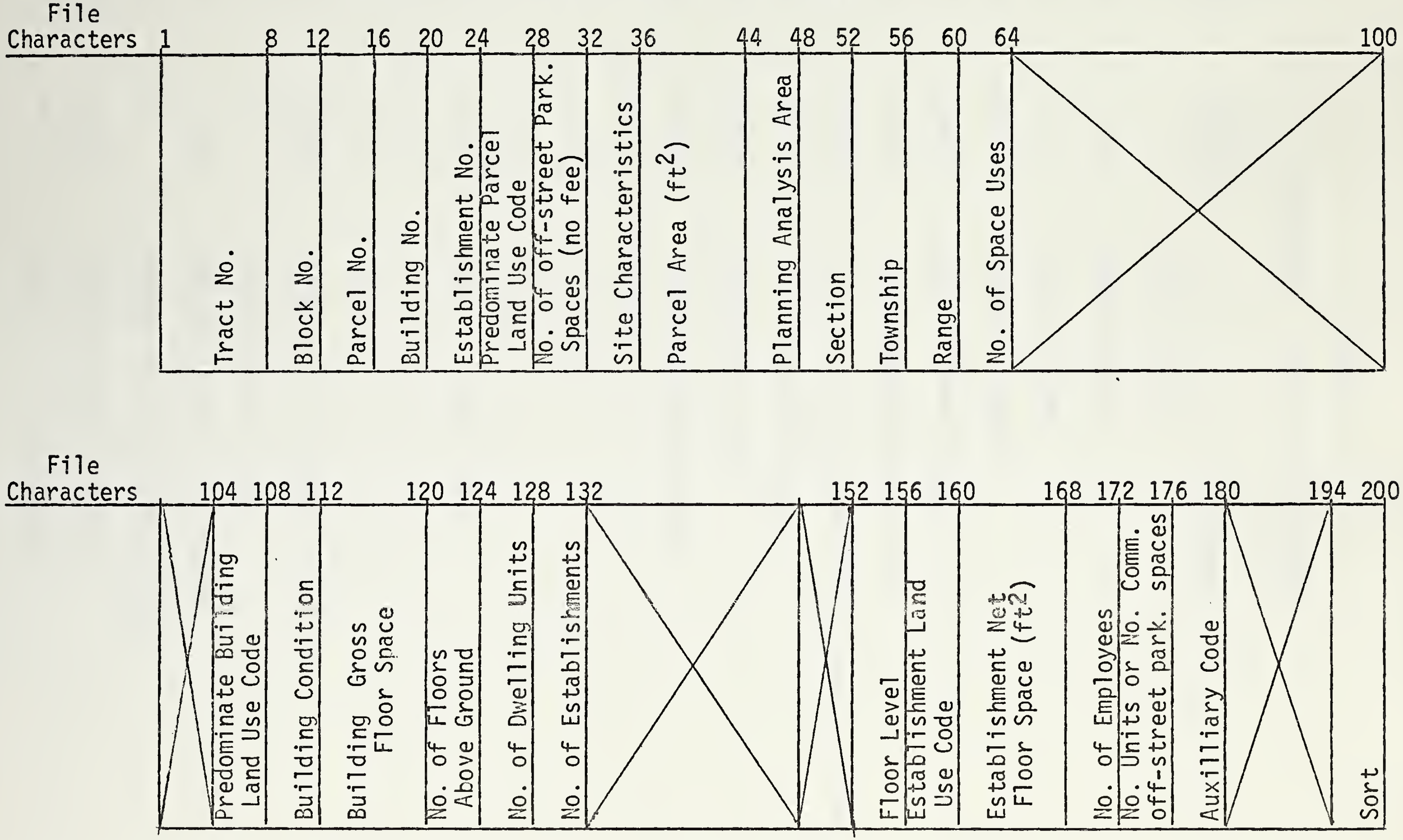
GENERAL

The transportation planning process uses as its basis the fact that various social and economic variables correlate well with the number of trips that are made. Because of this, equations can normally be found, using such independent varialbes as employment, dwelling units and population, that will mathematically duplicate the number of base year trip ends. Following the editing, expansion, and adjustment of the travel survey data, total 1970 productions and attractions for the Butte study area were available. Household characteristics (such as number of dwelling units) were available from the dwelling unit survey. These variables were used to develop trip generation equations for home-based work (HBW) trip productions and home-based other (HBO) trip productions. The procedures will be fully explained in Chapter VI.

The next phase required trip generation variables for the non-home end. Another source of data was required. During 1968-1969, the Butte-Silver Bow City-County Planning Board undertook the development of a comprehensive plan and retained the consulting firm of Howard, Needles, Tammen, and Bergendoff (HNTB) of Kansas City. As a part of the physical inventory for that plan, field data was collected and a land use file was created. All information was stored on computer tape using a basic record file containing 200 characters. The format of that file is illustrated

FIGURE V-1

BUTTE - SILVER BOW LAND USE FILE FORMAT



Source of Tape File: Comprehensive Plan, Howard, Needles, Tammen & Bergendoff

TABLE V-1

DICTIONARY - TAPE TO CARD FORMAT

Tape Position	Card Position	Record
1-8	1-3	Tract Number
9-12	4-6	Block Number
13-16	7-9	Parcel Number
17-20	10-11	Building Number
21-24	12-13	Establishment Number
25-28	14-15	Predominate Land Use Code
29-32	16-18	Number of Off-Street Parking Spaces (no fee)
33-36	19	Site Characteristics
37-44	20-27	Parcel Area (ft^2)
45-48	28-30	Planning Analysis Area
49-52	-----	Section
53-56	-----	Township
57-60	-----	Range
61-64	31-32	Number of Space Uses
65-100	-----	---
101-104	-----	---
105-108	33-34	Predominate Building Land Use
109-112	35	Building Condition
113-120	36-42	Building Gross Floor Space
121-124	43	Number of Floors Above Ground
125-128	44-45	Number of Dwelling Units
129-132	46-47	Number of Establishments

TABLE V-1 (continued)

Tape Position	Card Position	Record
133-152	-----	--
153-156	48	Floor Level
157-160	49-51	Establishment Land Use Code
161-168	52-58	Establishment Net Floor Space (ft^2)
169-172	59-62	Number of Employees
173-176	63-66	Number of Units or Number of Commercial Off-Street Parking Spaces
177-180	-----	Auxiliary Code
181-194	-----	--
195-200	-----	Sort
-----	70-72	Traffic Analysis Zone
-----	73-80	--

in Figure V-1. Upon examination of this figure, it can be seen that a wealth of information is available for each planning block; hence, this file was turned to as a source of further information.

To facilitate handling of the file data, the information which would be of further use in the transportation planning process was transferred to another tape and stored in an 80 column card format. The dictionary used to convert the tape file format to tape card format is illustrated in Table V-1. The purpose of this was to permit sorting of the file records by tract number and block number. Next, a separate set of cards containing tract number, block number, and traffic analysis zone was punched. After sorting these cards in the same sequence as the inventory file, the traffic analysis zones were inserted onto the inventory file card format. Note that Table V-1 contains the zone number in columns 70-72. At this point it was possible to summarize any data item on the tape by traffic analysis zone.

Before the consultant used the information from the land use tape file, a number of comparisons were made in order to substantiate the validity of the data. This was done to be certain the data was being extracted from the tape properly, and to verify that the figures received from the tape were reasonably close to those obtained from other sources. As documented in Tech-Plan Report 1, inconsistencies were found regarding the number of dwelling units and the employment. Thus, households per zone were obtained from the dwelling unit survey, and employment was determined from the Montana Employment Security and from telephone contact.

Employment for each zone and by land use type is tabulated in Table A-1 in the Appendix.

Figure V-1 illustrates that the land use inventory tape contains net floor space for each establishment. This data was summarized according to land use type and by traffic analysis zone. An independent data source was not available for comparisons, but the City-County Planning Board felt that this data was reliable for input to the multiple regression analyses. Hence, it was used as obtained from the tape.

The number of establishments per building and the number of units of off-street commercial parking were available from the inventory tape. This information was tabulated by zone and entered into regression analyses; however, these variables entered only as fourth or fifth order independent variables. They were not considered significant and were not used in any of the equations.

1970 TRIP GENERATION VARIABLES

The trip generation equations, as discussed and presented in Chapter VI, utilize seven variables and combinations, thereof. Table V-2 shows the study area totals for each variable. For a further breakdown to traffic analysis zone, the reader is referred to Table A-2 in the Appendix.

TABLE V-2

SUMMARY OF 1970

TRIP GENERATION VARIABLES

Variable	Source of Information	1970 Total
Dwelling Units		
Single Units	Dwelling Unit Survey	11,655
Multi-Family	Dwelling Unit Survey	3,410
Population	Dwelling Unit Survey & Expansion to 1970 Census Level	39,433
No. Persons 5 years & over	Dwelling Unit Survey	36,234
No. Employees (@ place of residence)	Dwelling Unit Survey	12,255
No. Employed (@ place of work)	Montana State Employment Security Division and Telephone contact with employers	13,488
No. Cars & Pickups	Dwelling Unit Survey	17,905
No. of Trucks	Truck Survey	888
Land Use Types No. 2 through 7 (ft^2)	Land Use Inventory Tape	10,098,638

CHAPTER VI

TRIP GENERATION ANALYSES

TRIP GENERATION ANALYSES

GENERAL

The mathematical process used to arrive at trip generation equations for this study is called stepwise multiple linear regression. The computer program BMD02R contained in the battery of biomedical statistical programs published by the University of California is the program utilized in this report. The program tests the independent variables input and forms regression equations for the dependent variables. Each step adds the independent variable which gives the greatest reduction in the residual sum of squares. Other statistical checks are made on the variables and the equations formed at each step. Figures VI-1 and VI-2 show how this program was implemented for the Butte Urban Transportation Study.

A six trip type stratification was used. Each type is explained in Tech-Plan Report 1. These six types - 1) home-based work, 2) home-based other, 3) non-home-based, 4) external, 5) truck, and 6) taxi trips, comprise the dependent variables for which equations were found in terms of independent variables, such as employment, floor space, dwelling units, etc. For each trip type, an equation was formed for production trips and for attraction trips.

In many previous studies a single equation was used for both production and attraction equations for truck, taxi, external and non-home based trips. A comparison was made on these trip types to see whether productions and attractions for each zone were relatively close so that one equation would suffice for both. Table VI-1 shows the results of

this comparison.

TABLE VI-1

% DEVIATION BETWEEN BASE YEAR PRODUCTIONS AND ATTRACTIONS

Trip Type	Average Zonal % Deviation
Non-Home Based	20.40
External	3.62
Trucks	11.10
Taxi	4.45

External, truck, and taxi comparisons were considered good enough to use a single equation for both production and attraction trips. Separate runs were made on both, and the equations with the best statistical indices were determined. Both production and attraction equations were derived for non-home based trips. The same variables entered with the same order for both equations, and their coefficients were nearly equal. Based on this analysis, it was decided to use a single equation for non-home based productions and attractions.

Before regression trials were carried out, each zone was checked to determine whether it reflected urban or rural characteristics, and whether it reflected the trip generation characteristics of the Butte Urban Area. Twelve zones were deleted from the analysis, eleven of them because in the the base year they were essentially rural areas. One other, i.e., zone 64, was eliminated because it contained vacant land, and had no employment, industry, dwelling units, or other independent variables from which trips could be predicted. These zones are listed in Table VI-2.

TABLE VI-2

ZONES OMITTED FROM TRIP GENERATION ANALYSES

Rural Zones:	37, 54, 70, 106, 109, 110, 111, 112, 113, 114, 115
Vacant Zone:	64

The regression equations chosen for predicting 1990 trips were applied to these twelve zones on the assumption that they would reflect urban characteristics by 1990. This assumption was supported by the 1990 Land Use Plan.

Numerous tests were conducted to arrive at equations which would best reflect the trip generation characteristics of the study area. Initially, equations were derived in which all of the independent variables were tested. Many of the variables entered showed good statistical indices but were rejected for one (or all) of the following reasons:

1. The independent variable was not logically related to the dependent variable.
2. Projections to 1990 could not be obtained with proper accuracy.
3. Independent variables entering the equations showed a high correlation with each other.

New trials were made in which some variables were control-deleted.

The equations formed at each trial were checked on a district basis comprised of the zones shown in Table VI-3. The reader is referred to Figure A-1 in the Appendix for zone boundaries.

Table VI-3

DISTRICT BOUNDARIES FOR MULTIPLE REGRESSION

District	Zones
1	1-23
2	24-33
3	34-39
4	40-49
5	50-56
6	57-66
7	67-73
8	74-78
9	79-88
10	89-96
11	97-115

If the trip predictions for a particular district did not correspond with the actual number of trips, each zone within that district was checked to see whether it should be classified as a "special" zone. These "special" zones were not included in further analyses. A third run was performed with these zones deleted. The results usually yielded a satisfactory trip generation equation. The last step was to apply the resulting equation to the special zones and check the trip comparisons.

Initially, all trials for home-based other attractions (HBOA) and non-home based production and attractions (NHBP&A) resulted in unsatisfactory equations. A run in which the study area was divided into the

older and newer sections of Butte was tried, because many of the zones not fitting the equations previously derived were in the "older" areas of Butte. Acceptable equations were not found for both of these areas. Further examination of previous runs revealed a constant term entering into the equations; in most cases this constant was near to or larger than the number of trips in many of the zones. A trial was made in which the equations were forced through the origin to eliminate the constant term. The new equations predicted well, although some "special" zones had to be deleted. Another trial was then made on the remaining zones, again forcing the equation through the origin, and the final home based other attraction (HBOA) and non-home based production and attraction equations (NHBP&A) were determined.

The next two sections of this chapter give statistics for the home-based regression results and the zonal regression results. The final section gives a summary of these analyses.

HOME-BASED PRODUCTION REGRESSION ANALYSES

The variables tested for significance in the home-based regression analysis are shown in Table VI-4 along with their abbreviations, means and standard deviations. Each is tabulated by dwelling units. For instance, pickups (PICKUP) means pickups per dwelling unit.

TABLE VI-4

VARIABLES FOR HOME-BASED PRODUCTION REGRESSION ANALYSES

Variable	Abbreviation	Mean	Standard Deviation
1. Structure Type	STRTYP	1.59812	1.42453
2. Autos	AUTOSX	0.95518	0.80910
3. Pickups	PICKUP	0.24331	0.46935
4. Persons	PERSNS	2.66817	2.05017
5. Persons 5 & Over	5&OVER	2.44331	1.82590
6. Transit Bus Trips	TRABUS	0.05800	0.35526
7. Car Trips	CARTPS	3.48625	4.57033
8. Pickup Trips	P.TRIPS	0.48437	2.13664
9. Drivers With Trips	DR.WTR	0.88588	0.85103
10. Drivers Without Trips	DR.W/O	0.48738	0.72916
11. Drivers With Unknown Trips	DR.UNN	0.00452	0.10621
12. Employed	EMPLOY	0.82524	0.74994
13. Students	STUDNT	0.82976	1.49115
14. Home Based Work Trips (produced)	HBWP//	0.91864	1.30090
15. Non-Home Based Trips	NHB///	1.13333	2.69829
16. Home Based Other Trips (productions)	HBOP//	1.74991	2.64646
17. Total Trips	TOTALS	3.93220	5.00788
18. Vehicles	VEHCLE	1.19849	0.97985

Many of these variables, i.e. numbers - 6, 7, 8, 9, 10, 11, 15, and 17 were entered into the program so that their means, standard deviations, and correlations could be determined even though they are not considered suitable variables for entry into the regression equations.

The correlations of the 18 home based regression variables are given in Table VI-5. They are provided as a comparison of linear relationships between any two variables used in the analyses. For example, HBWP and EMPLOY have a correlation of 0.582 which indicates that work trips produced at any residence are significantly related to the number of workers residing at that residence.

FIGURE VI-1

DWELLING UNIT REGRESSION

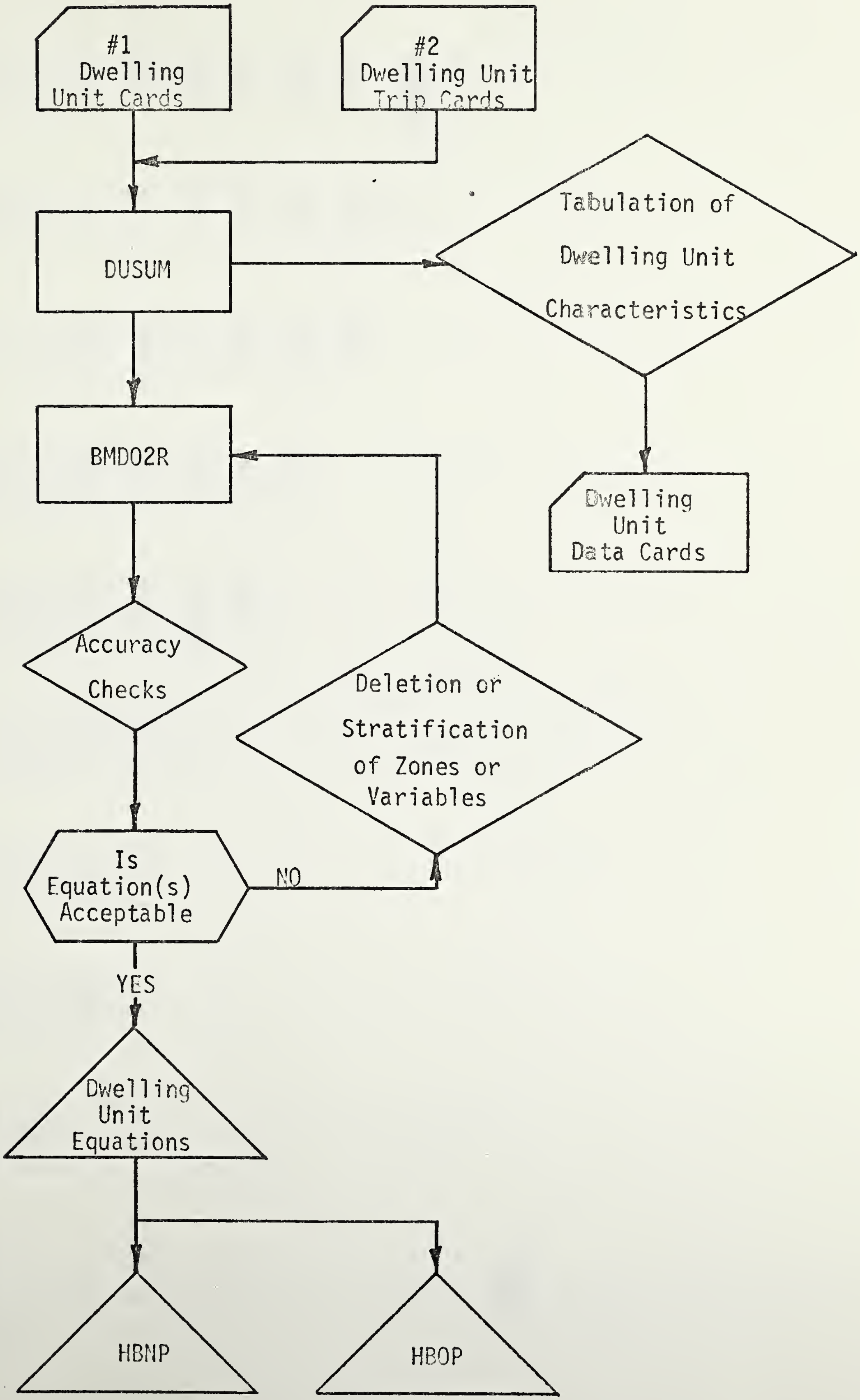

#1 Dwelling Unit Cards
#2 Dwelling Unit Trip Cards
DUSUM
Tabulation of Dwelling Unit Characteristics
Dwelling Unit Data Cards
BMDO2R
Accuracy Checks
Deletion or Stratification of Zones or Variables
Is Equation(s) Acceptable
NO
YES
Dwelling Unit Equations
HBNP
HBOP

TABLE VI-5

CORRELATION MATRIX FOR HBP REGRESSION ANALYSES

Variable	1	2	3	4	5	6	7	8	9
1.	1.000	-0.235	-0.126	-0.232	-0.247	0.010	-0.194	-0.053	-0.240
2.		1.000	0.112	0.499	0.515	-0.041	0.568	0.057	0.662
3.			1.000	0.308	0.303	0.017	0.084	0.392	0.338
4.				1.000	0.946	0.057	0.414	0.147	0.528
5.					1.000	0.069	0.424	0.136	0.542
6.						1.000	-0.039	0.012	-0.038
7.							1.000	-0.012	0.707
8.								1.000	0.224
9.									1.000
10.									
11.									
12.									
13.									
14.									
15.									
16.									
17.									
18.									

TABLE VI-5 (continued)

CORRELATION MATRIX FOR HBP REGRESSION ANALYSES

Variable	10	11	12	13	14	15	16	17	18
1.	-0.115	-0.015	-0.206	-0.161	-0.140	-0.114	-0.173	-0.196	-0.255
2.	0.290	0.002	0.552	0.342	0.460	0.309	0.452	0.539	0.879
3.	0.136	0.016	0.311	0.218	0.265	0.104	0.195	0.237	0.572
4.	0.377	0.033	0.507	0.855	0.361	0.228	0.397	0.439	0.559
5.	0.390	0.042	0.523	0.888	0.370	0.224	0.405	0.444	0.571
6.	-0.019	0.003	-0.024	0.095	-0.014	-0.012	-0.030	-0.030	-0.026
7.	-0.000	-0.032	0.452	0.323	0.392	0.667	0.803	0.902	0.509
8.	-0.012	-0.010	0.157	0.097	0.174	0.480	0.171	0.399	0.235
9.	-0.063	-0.044	0.618	0.380	0.624	0.398	0.640	0.735	0.709
10.	1.000	-0.024	0.254	0.302	-0.017	-0.006	0.010	-0.002	0.305
11.		1.000	0.010	0.036	-0.030	-0.018	-0.028	-0.033	0.009
12.			1.000	0.319	0.582	0.261	0.322	0.477	0.605
13.				1.000	0.245	0.177	0.319	0.336	0.386
14.					1.000	0.187	0.152	0.444	0.521
15.						1.000	0.430	0.821	0.312
16.							1.000	0.811	0.469
17.								1.000	0.559
18.									1.000

The two dwelling unit equations found to be most acceptable along with their statistical indices are:

1. HBWP/D.U. = 1.00961 (EMPLOY/D.U.) + 0.08548

   Multiple R = 0.5820

   Standard Error of Estimate = 1.0581

   Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	1521.472	1521.472	1359.071
Residual	2970.020	1.119	

   Variables in Equation

   (Constant = 0.08548)

Variable	Coefficient	Standard Error	F to Remove
EMPLOY	1.00961	0.02739	1359.0723

---

2. HBOP/D.U. = 0.47148 (5 & Over/D.U.) + 0.53642 (EMPLOY/D.U.)

   Multiple R = 0.4250

   Standard Error of Estimate = 2.3964

   Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	3357.672	1678.836	292.330
Residual	15230.285	5.743	

   Variables in Equation

   (Constant = 0.15526)

Variable	Coefficient	Standard Error	F to Remove
5&OVER	0.47148	0.02989	248.8303
EMPLOY	0.53642	0.07277	54.3367

To arrive at equations on a zonal level, equations (1) and (2) above must be multiplied by dwelling units per zone. The results are:

3. HBWP/ZONE = 1.00961 (EMPLOY/ZONE) + 0.08548 (D.U./ZONE)
4. HBOP/ZONE = 0.47148 (5&OVER/ZONE) + 0.15526 (D.U./ZONE)

Equations (3) and (4) must be multiplied by the screenline factors for home-based work and home-based other trips. The factors are, respectively, 1.00 and 1.98, and the equations are:

5. HBWP/ZONE = 1.00961 (EMPLOY/ZONE) + 0.08548 (D.U./ZONE)
6. HBOP/ZONE = 0.93353 (5&OVER/ZONE) + 1.06211 (EMPLOY/ZONE) + 0.30741 (D.U./ZONE)

These equations were checked on a zone basis, and it was found that the HBOP equation did not predict well for the Central Business District (CBD) and zones 26, 31, 39, 36, and 47. Figure A-1 illustrates that these zones are located around the Central Business District and exhibit characteristics of an older residential area. These were considered special zones and the equation was adjusted to arrive at the following home-based regression equations.

7. HBWP/ZONE = 1.00961 (EMPLOY/ZONE) + 0.08548 (D.U./ZONE)
8. HBOP/ZONE = 1.01475 (5&OVER/ZONE) + 1.15451 (EMPLOY/ZONE) + 0.33415 (D.U./ZONE)

ZONAL REGRESSION ANALYSES

The variables tested for significance in the zonal regression analysis are shown in Table VI-6 along with their abbreviations, means, and standard

deviations. Each is tabulated by zones. For instance, vehicles (VEHCLE) means vehicles per zone.

TABLE VI-6

ZONAL REGRESSION ANALYSIS VARIABLES AND THEIR SIGNIFICANCE

Variable	Abbreviation	Mean	Standard Deviation
1. Occupied Dwelling Units	DUOCCU	130.92055	126.87823
2. Vacant Dwelling Units	DUVACT	13.29023	17.83083
3. Persons (Population	PERSNS	377.98633	392.82886
4. Person 5 & Over	5&OVER	346.05127	357.65601
5. Employees	EMPLOY	116.33316	124.12366
6. Students	STUDNT	116.16940	133.70889
7. Automobiles	CARSXX	135.64854	146.19876
8. Total Vehicles	VEHCLE	170.28261	181.64696
9.* Produce & Light Manufacturing Floor Space	MFTR P	1478.67944	4682.55859
10.* Commercial & Heavy Manufacturing Floor Space	MFTR C	876.25220	5788.22266
11.* Transportation and Utilities Floor Space	TRANSU	19593.94141	113313.81250
12.* Retail Floor Space	RETAIL	25163.36719	53064.67188
13.* Service and Office Floor Space	SERVCS	45539.51172	89026.56250
14.* Entertainment Floor Space	ENTANT	5225.73438	20839.73438

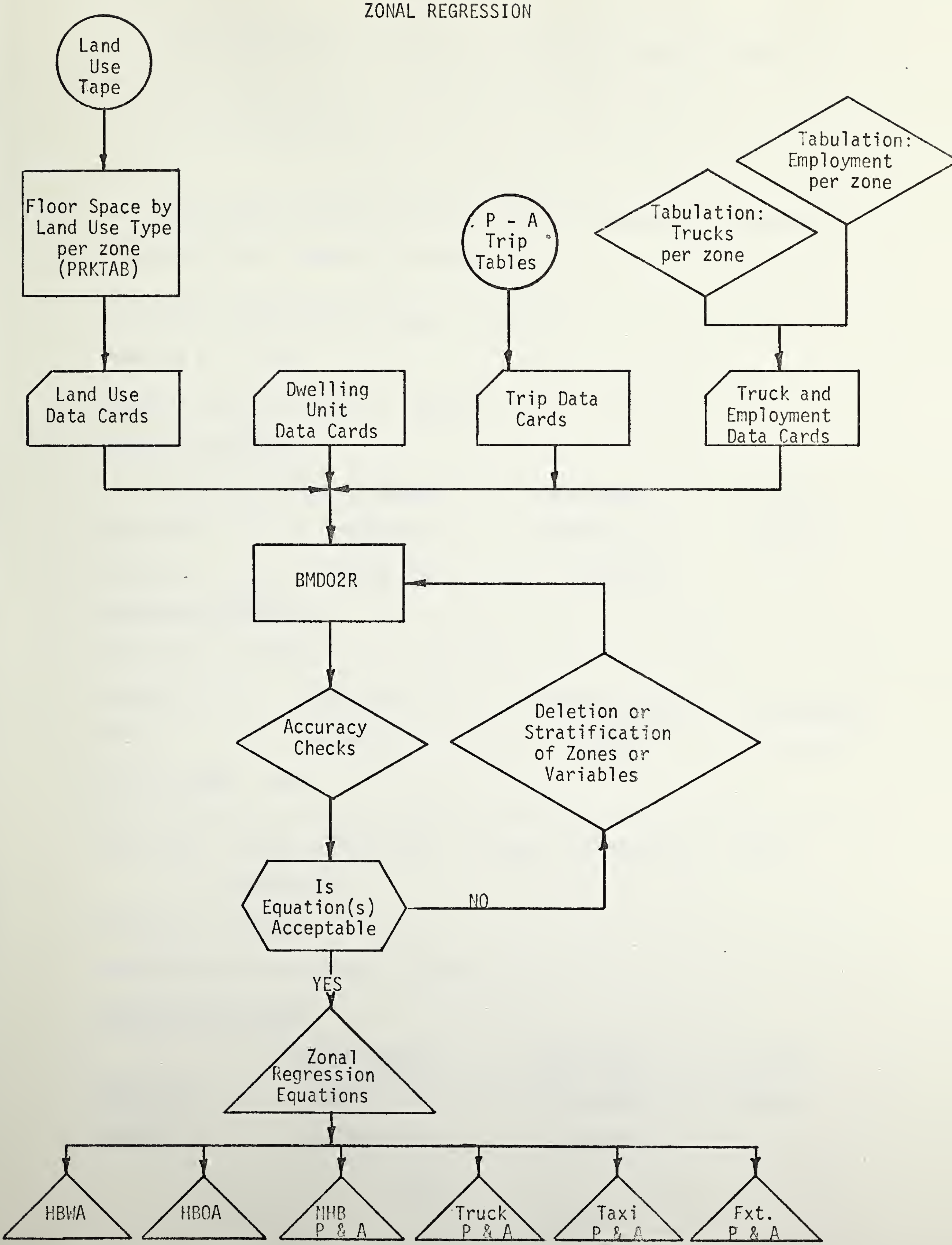
TABLE VI-6 (continued)

Variable	Abbreviation	Mean	Standard Deviation
15.* Mining and Resource Production Floor Space	MINING	2216.19409	14854.03516
16. Square Feet of Undeveloped Land	UNDEVL	16783.98047	97683.25000
17.* Vacant Floor Space	VCNTFL	16136.35547	57401.78516
18. Establishments	ESTABL	152.23300	130.25383
19. Trucks	TRUCKS	13.83495	16.65981
20. Employment	EMPLMT	132.65048	251.91534
21. Home Based Work Trips Attracted	HBWA	129.03883	193.13411
22. Taxi Trip Productions and Attractions	TAXI P	15.73786	17.26317
23. Total Dwelling Units	TOT.DU	146.47536	135.94385
24. Total Commercial Floor Space (9+10+11+12+13+14)	COMFLR	101119.00000	159239.93750
25. External Trip Production and Attractions	EXTP&A	43.06122	37.78755
26. Home Based Other Trip Attractions	HBOA	434.98096	457.68628
27. Non-Home Based Trips Productions	NHBP	231.48102	194.24474
28. Non-Home Based Trip Attractions	NHBA	220.13101	177.08015
29. Truck Trip Productions and Attractions	TRUCK P&A	655.11353	606.23535

* In square feet of floor space per zone.

FIGURE VI-2

ZONAL REGRESSION


Land Use Tape
Floor Space by Land Use Type per zone (PRKTAB)
P - A Trip Tables
Tabulation: Trucks per zone
Tabulation: Employment per zone
Land Use Data Cards
Dwelling Unit Data Cards
Trip Data Cards
Truck and Employment Data Cards
BMD02R
Accuracy Checks
Deletion or Stratification of Zones or Variables
Is Equation(s) Acceptable
NO
YES
Zonal Regression Equations
HBWA
HBOA
NHB P & A
Truck P & A
Taxi P & A
Ext. P & A

The correlations of these 29 variables are given in Table VI-7.

The zonal regression equations found to be the most acceptable along with their statistical indices are:

HBWA/ZONE = 0.69011 (EMPLMT/ZONE) + 37.49493

Multiple R = 0.9002

Standard Error of Estimate = 84.5396

Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	3082836.000	3082836.000	431.350
Residual	721842.188	7146.949	

Variables in Equation

(Constant = 37.49493)

Variable	Coefficient	Standard Error	F to Remove
EMPLMT	0.69011	0.03323	431.3499

Special Zones: None

HBOA/ZONE = 1.29510 (EMPLMT/ZONE) + 1.41913 (TOT.DU/ZONE) + 0.00115 (COMFLR/ZONE

Multiple R = 0.8963

Standard Error of Estimate = 0.00115

Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	21955296.000	7318432.000	98.050
Residual	5374066.000	74639.750	

TABLE VI-7

CORRELATION MATRIX FOR ZONAL REGRESSION ANALYSES

Variable	1	2	3	4	5	6	7	8	9	10
1	1.000	0.457	0.970	0.969	0.949	0.865	0.949	0.935	-0.012	0.039
2		1.000	0.328	0.331	0.291	0.183	0.281	0.242	0.100	0.057
3			1.000	0.998	0.984	0.948	0.980	0.982	-0.028	0.030
4				1.000	0.985	0.954	0.982	0.982	-0.031	0.029
5					1.000	0.926	0.987	0.989	-0.042	0.022
6						1.000	0.926	0.940	-0.057	0.022
7							1.000	0.993	-0.052	-0.003
8								1.000	-0.041	-0.002
9									1.000	0.306
10										1.000
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										

TABLE VI-7 (Continued)

CORRELATION MATRIX FOR ZONAL REGRESSION ANALYSES

Variable	11	12	13	14	15	16	17	18	19	20
1	-0.099	-0.171	0.268	0.257	0.001	-0.147	0.065	0.836	0.150	-0.066
2	-0.055	0.030	0.151	0.169	0.169	-0.032	0.199	0.344	0.028	0.010
3	-0.102	-0.194	0.255	0.234	-0.006	-0.130	0.021	0.858	0.146	-0.087
4	-0.101	-0.194	0.248	0.243	-0.010	-0.130	0.029	0.853	0.142	-0.087
5	-0.096	-0.187	0.248	0.187	-0.034	-0.137	0.026	0.845	0.147	-0.092
6	-0.096	-0.190	0.196	0.291	-0.051	-0.095	-0.019	0.795	0.097	-0.091
7	-0.106	-0.202	0.292	0.203	-0.028	-0.142	0.023	0.837	0.168	-0.081
8	-0.107	0.202	0.277	0.190	-0.040	-0.127	-0.002	0.843	0.162	-0.096
9	-0.021	0.045	0.050	-0.066	0.014	-0.055	0.012	0.034	0.269	0.002
10	-0.019	0.035	-0.018	-0.036	0.068	-0.026	0.019	0.113	0.181	-0.005
11	1.000	0.056	-0.020	-0.038	-0.019	-0.570	-0.023	-0.088	0.239	0.052
12		1.000	-0.018	-0.064	-0.053	-0.068	0.086	-0.132	0.374	0.109
13			-0.020	0.154	0.008	-0.046	0.039	0.269	0.216	0.091
14				1.000	-0.037	-0.044	-0.060	0.189	-0.023	0.070
15					1.000	-0.017	-0.031	0.088	0.005	0.130
16						1.000	-0.044	-0.121	0.082	0.004
17							1.000	0.031	-0.070	0.020
18								1.000	0.203	-0.033
19									1.000	0.153
20										1.000
21										
22										
23										
24										
25										
26										
27										
28										
29										

TABLE VI-7 (continued)

CORRELATION MATRIX FOR ZONAL REGRESSION ANALYSES

Variable	21	22	23	24	25	26	27	28	29
1	-0.111	0.468	0.993	0.058	0.316	0.164	0.255	0.198	0.119
2	0.105	0.566	0.557	0.084	0.185	0.207	0.243	0.253	0.141
3	-0.133	0.350	0.948	0.037	0.328	0.166	0.232	0.178	0.124
4	-0.134	0.353	0.923	0.035	0.321	0.162	0.230	0.177	0.121
5	-0.146	0.300	0.831	0.033	0.310	0.134	0.211	0.162	0.101
6	-0.140	0.249	0.922	0.015	0.316	0.200	0.234	0.179	0.128
7	-0.139	0.312	0.904	0.046	0.316	0.146	0.230	0.165	0.118
8	-0.152	0.265	0.002	0.036	0.330	0.154	0.222	0.165	0.115
9	0.005	-0.009	0.044	0.061	0.060	-0.052	-0.039	-0.018	0.108
10	0.008	-0.016	-0.100	0.029	0.017	-0.022	-0.037	-0.027	0.140
11	0.045	0.027	-0.156	0.726	-0.018	0.175	0.315	0.312	0.193
12	0.159	0.112	0.270	0.364	0.162	0.260	0.338	0.353	0.223
13	0.088	0.219	0.262	0.570	0.073	0.155	0.244	0.113	0.149
14	0.047	0.245	0.023	0.169	0.106	0.245	0.266	0.158	0.066
15	0.207	0.129	-0.141	-0.029	-0.023	-0.040	-0.050	-0.047	0.095
16	0.090	-0.045	0.087	0.402	0.264	0.456	0.407	0.480	0.210
17	-0.013	0.112	0.825	0.028	-0.036	-0.003	0.031	0.058	-0.087
18	-0.071	0.379	0.144	0.076	0.312	0.139	0.244	0.152	0.222
19	0.123	0.091	-0.060	0.435	0.169	0.108	0.221	0.195	0.574
20	0.900	0.229	-0.090	0.136	0.248	0.142	0.245	0.136	0.581
21	1.000	0.187	0.270	0.144	0.308	0.259	0.327	0.275	0.635
22		1.000	0.511	0.214	0.238	0.271	0.424	0.263	0.219
23			1.000	0.065	0.319	0.181	0.270	0.218	0.129
24				1.000	0.100	0.333	0.515	0.430	0.318
25					1.000	0.732	0.629	0.667	0.461
26						1.000	0.882	0.880	0.396
27							1.000	0.918	0.434
28								1.000	0.393
29									1.000

Variables in Equation

(Constant = 0.0)

Variable	Coefficient	Standard Error	F to Remove
EMPLMT	1.29510	0.22971	27.7647
TOT.DU	1.41913	0.20268	42.8214
COMFLR	0.00115	0.00020	29.5420

Special Zones: District #2; Zones 7, 51, 73, 82, 84, 92, and 94

NHBP&A/ZONE = 0.64909 (EMPLMT/ZONE) + 0.63829 (TOT.DU/ZONE) + 0.00057 (COMFLR/ZONE)

Multiple R = 0.9154

Standard Error of Estimate = 129.3915

Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	5850455.000	1950151.000	124.031
Residual	1132059.000	15723.039	

Variables in Equation

(Constant = 0.0)

Variable	Coefficient	Standard Error	F to Remove
EMPLMT	0.64909	0.10543	37.9060
TOT.DU	0.63829	0.09302	47.0819
COMFLR	0.00057	0.00009	39.9300

Special Zones: 51, 92

EXTP&A/ZONE = 0.12808 (TOT.DU/ZONE) + 0.06827 (EMPLMT/ZONE) + 13.51288

Multiple R = 0.6499

Standard Error of Estimate = 24.2874

Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	40980.645	20490.320	34.737
Residual	56038.168	589.875	

Variables in Equation

(Constant = 13.51288)

Variable	Coefficient	Standard Error	F to Remove
TOT.DU	0.12808	0.01816	49.7289
EMPLMT	0.06827	0.01671	16.6977

Special Zones: 28, 30, 92

TRUCKP&A/ZONE = 1.97439 (TRUCKS/ZONE) + 0.05357 (EMPLMT/ZONE) + 12.88955

Multiple R = 0.7394

Standard Error of Estimate = 24.1186

Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	66645.875	33322.938	57.285
Residual	55262.250	581.708	

Variables in Equation

(Constant = 12.88955)

Variable	Coefficient	Standard Error	F to Remove
TRUCKS	1.97439	0.15118	77.3421
EMPLMT	0.05357	0.01721	12.1978

Special Zones: 51

TAXIP&A/ZONE = 0.19973 (TOT.DU/ZONE) - 0.10833 (VEHCLE/ZONE) + 5.83800

Multiple R = 0.6930

Standard Error of Estimate = 13.2045

Analysis of Variance

	Sum of Squares	Mean Square	F Ratio
Regression	16110.059	8055.027	46.198
Residual	17435.813	174.358	

Variables in Equation

(Constant = 5.83800)

Variable	Coefficient	Standard Error	F to Remove
TOT.DU	0.19973	0.02255	78.4502
VEHCLE	-0.10833	0.01688	41.1994

Special Zones: None

SUMMARY

The following variables were found to enter into the equations used for predicting trips in the Butte Urban Transportation Study.

Variables

Employees

Persons 5 & over

Employment

Vehicles

Total Dwelling Unit

Total Commercial Floor Space

Trucks

The final equations are as follows:

TABLE VI-8

TRIP GENERATION EQUATIONS

1. HBWP/ZONE = 1.00961 (EMPLOY/ZONE) + 0.08548 (D.U./Zone)

   Special Zones: None

2. HBWA/ZONE = 0.69011 (EMPLMT/ZONE) + 37.49493

   Special Zones: None

3. HBOP/ZONE = 1.01475 (5&OVER/ZONE) + 1.15451 (EMPLOY/ZONE) + 0.33415 (D.U./ZONE)

   Special Zones: 1-23, 26, 31, 39, 36, 47

4. HBOA/ZONE = 1.29510 (EMPLMT/ZONE) + 1.41913 (TOT.DU/ZONE + 0.00115 (COMFLR/ZONE)

   Special Zones: District 2, 7, 51, 73, 82, 84, 92, 94

5. NHBP&A/ZONE = 0.64909 (EMPLMT/ZONE) + 0.63829 (TOT.DU/ZONE) + 0.00057 (COMFLR/ZONE)

   Special Zones: 51,92

6. EXTP&A = o.12808 (TOT.DU/ZONE) + 0.06827 (EMPLMT/ZONE) + 13.51288

   Special Zones: 28,30,92

7. TRUCKP&A = 1.97439 (TRUCKS/ZONE + 0.05357 (EMPLMT/ZONE) + 12.88955

   Special Zones: 51

8. TAXIP&A/ZONE = 0.19973 (TOT.DU/ZONE) - 0.10833 (VEHCLES/ZONE) + 5.83800

   Special Zones: None

Table VI-9 lists the special zones referred to in these analyses and states the general characteristics of each zone.

TABLE VI-9

CHARACTERISTICS OF SPECIAL ZONES

Zones	Characteristics
1-23	Central Business District
24-33 (District 2)	Zones North and Northeast of CBD, including Walkerville. Zones 28 and 30 have active mines.
36	Residential bordering Northwest of CBD.
39	Residential bordering the West side of the CBD
47	General Industry Southeast of CBD
51	Berkeley Pit
73	Commercial/Residential zone on Harrison Avenue
82	Residential/Rural on Eastern side of study area
84	Residential zone
92	Shopping center
94	Commercial/Residential zone on Harrison Avenue

CHAPTER VII

GRAVITY MODEL CALIBRATION

GRAVITY MODEL CALIBRATION

The gravity model is an equation which can be calibrated or adjusted to distribute 1990 trips in the same pattern as the base year reported trips.

The equation is:

$$T_{ij} = P_i \frac{A_j \quad F_{ij} \quad K_{ij}}{\sum_{j=1}^{n} A_j \quad F_{ij} \quad K_{ij}}$$

Where:

T_{ij} = Trips produced in zone and attracted in zone

P_i = Trips produced in zone

A_j = Trips attracted in zone

F_{ij} = Derived travel time factor. This expresses the average effect of spacial seperation on trip interchanges between zones and

It was derived for each minute of travel time increment.

K_{ij} = A zone to zone adjustment factor to allow for the effect on travel patterns of social or economic differences not otherwise accounted for by the gravity model.

n = number of zones

Traveltime factors, F_{ij}, express the effect that spacial separation exerts on trip interchanges. They indicate the impedence to interzonal travel due to spacial separation between zones. These factors express the

the probability of trip making at each one-minute interval. It is assumed here that these trip making characteristics do not change over time. Gravity model calibration is the process of adjusting these "F" factors until the trip distribution predicted by the gravity model is the same, or within acceptable limits, as the actual trip distribution within the study area.

The study used six trip purposes, i.e., Home Based Work, Home Based Other, Non-Home Based, External - Internal, Truck, and Taxi Trips. Calibration of the gravity model for the Butte Urban Transportation Study required finding six sets of F Factors, a set for each trip purpose.

Figure VII-7 illustrates the work activities performed in calibration of the model. The first step was to determine terminal and intrazonal traveltimes. Spacial separation between zones is more realistically approximated by "door-to-door" traveltimes than by "driving times". Zone to zone traveltimes are the sum of the over-the-road driving times between zones plus the terminal times within the origin and destination zones. Consequently, it is necessary to develop terminal times for each zone. For this study terminal times were determined on the following basis: One minute walking time plus two minutes circulation time for central business district zones, one minute walking time for fringe business districts, and two minute walking times for zones along Harrison Avenue which have a high degree of commercial activity.

These procedures for arriving at terminal times do not yield a measure of time for trips that do not leave a particular zone. This intrazonal

driving time was derived separately by determining the driving times from a zone to each adjacent zone. Intrazonal times used were one-half the average of these times. The terminal and intrazonal traveltimes were incorporated into the "driving time" skim trees using the program UPTREE.

The gravity model calibration program, GMCAL, was used to determine final F factors for the Gravity Models. Initial F factors for the first five trip purposes were taken from the Helena Transportation Study. The sixth trip purpose, i.e., taxi trips, were initialized at one (1). Each run of GMCAL produces new adjusted and smoothed F factors. These new F factors were checked against the distributions of each trip type and new F factors for the next trial of GMCAL determined. Numerous runs of GMCAL on the six trip stratifications brought the percent root mean squared error between the calculated distribution and the actual base year distribution to within ± 3% for each trip type. This is considered within acceptable limits and the corresponding F factors were considered satisfactory.

Tables VII-1 through VII-6 and Figures VII-1 through VII-6 illustrate the comparison between the 1970 origin destination trip distribution and the distribution calculated by the calibrated Gravity Models. In most cases the distributions are so nearly alike that the lines on the graphs coincide. Also shown in the tables are the final friction (or F) factors.

In addition to the percent root mean square error, three other statistics were used in calibration of the Gravity Models. A level of significance of 98% was chosen, and the corresponding value of Chi-Squared, χ^2, with 20-3=17 degress of freedom is 30.995. The Chi-squared factor

for each model was progressively reduced as the model distributions more nearly approximated the O-D data. Since the Chi-Squared factor for each model is below 30.995 (the largest χ^2 is for taxi trips @ 6.980), it can be stated with 98% confidence that the calculated distributions are not statistically different from the observed distributions.

The GMCAL program also computes the Chi-Square probability for the calculated distribution. Tables VII-1 through VII-6 indicate that for each model the probability is nearly one (1). The difference between one (1.0000) and the calculated Chi-Squared probability is the probability that some other distribution will result. Examination shows that for each of the six models, this probability is the greatest for truck trips (0.0100411). The other models have probabilities much lower than this.

Another statistic computed by GMCAL is the coefficient of correlation. Throughout the iterative trials of calibrating the models, this coefficient increased its value from between 0.50 and 0.60. This indicated a greater correlation between the two trip distributions.

Each of the above statistical measures were examined during each trial. The tables and figures on the following pages show these values for the final calibration. F factors illustrated are those that were used with the Gravity Model (GM) computer program for distribution of 1990 trips. This procedure will be explained in future reports.

Since it was possible to reduce the % root mean square error to within acceptable limits and other statistics indicated satisfactory results, social-economic adjustment factors (K_{ij}) were assigned a value of one (1).

The individual work activities described above are illustrated by the flow chart in Figure VII-7 at the end of this chapter.

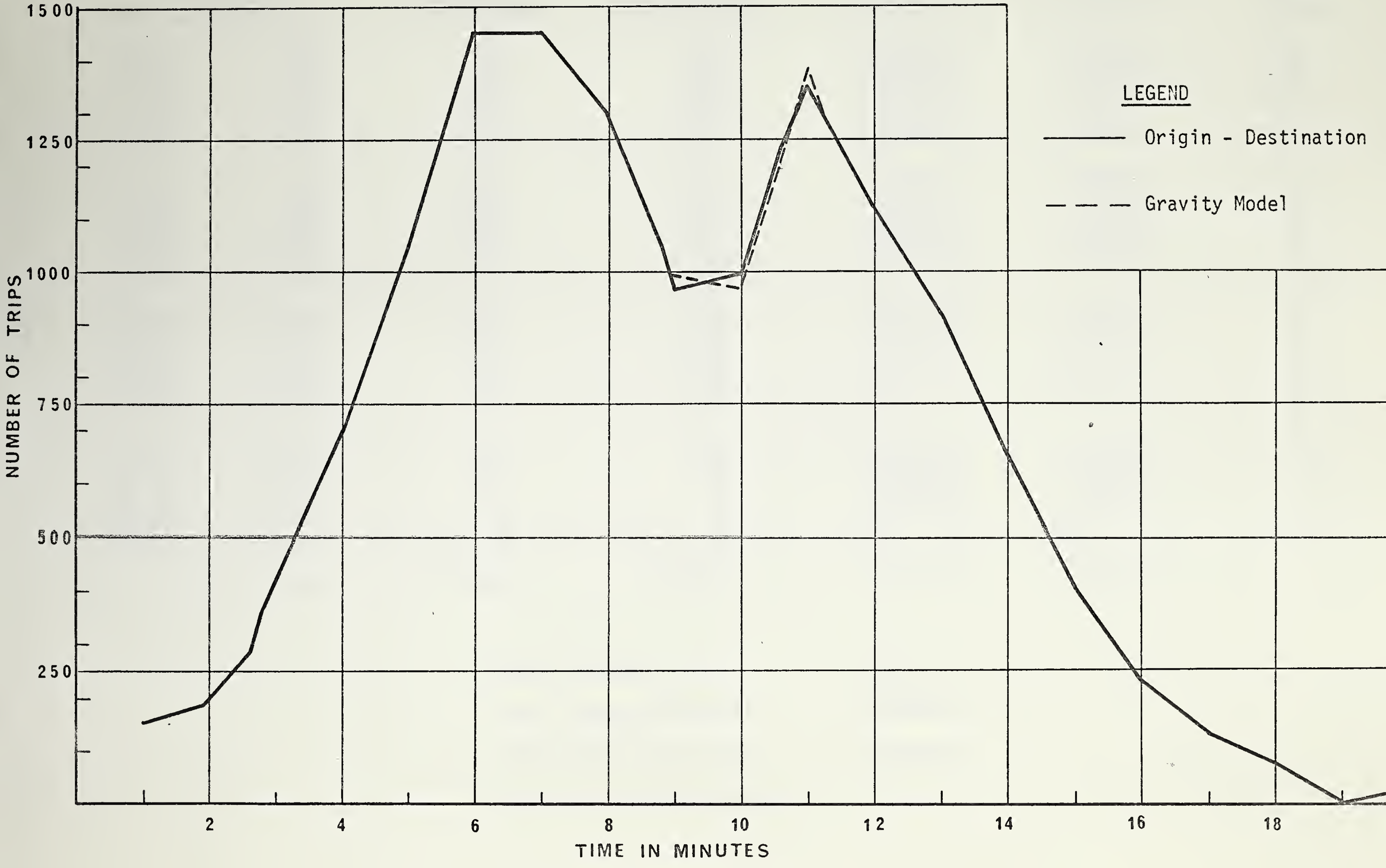
TABLE VII-1
GRAVITY MODEL CALIBRATIONS
for
Home Based Work Trips

Trip Length		Observed	Calculated	Squared	Chi - Squared	F Factor
From -	To Excluding	Distribution	Distribution	Difference	Factor	Used
Zero	2.00	152	155	9.000E 00	5.921E-02	187
2.00	3.00	182	182	0.0	0.0	100
3.00	4.00	367	368	1.000E 00	2.725E-03	104
4.00	5.00	686	683	9.000E 00	1.312E-02	116
5.00	6.00	1,057	1,060	9.000E 00	8.515E-03	95
6.00	7.00	1,451	1,451	0.0	0.0	94
7.00	8.00	1,457	1,457	0.0	0.0	76
8.00	9.00	1,272	1,272	0.0	0.0	71
9.00	10.00	983	989	3.600E 01	3.662E-02	64
10.00	11.00	985	982	9.000E 00	9.137E-03	71
11.00	12.00	1,367	1,368	1.000E 00	7.315E-04	75
12.00	13.00	1,163	1,162	1.000E 00	8.598E-04	79
13.00	14.00	924	921	9.000E 00	9.740E-03	67
14.00	15.00	660	660	0.0	0.0	70
15.00	16.00	413	410	9.000E 00	2.179E-02	65
16.00	17.00	221	221	0.0	0.0	64
17.00	18.00	121	120	1.000E 00	8.264E-03	62
18.00	19.00	73	73	0.0	0.0	121
19.00	20.00			0.0	0.0	
20.00	and over	32	32	0.0	0.0	86
	TOTAL	13,566	13,566	9.400E 01	1.707E-01	

Root Mean Square Error	2.2242670
Chi - Square Probability	0.99999750
% Root Mean Square Error	0.31152183
Coefficient of Correlation	0.56853932

FIGURE VII-1

HOME BASED WORK TRIP DISTRIBUTION



# TABLE VII-2
# GRAVITY MODEL CALIBRATIONS
for
Home Based Other Trips

Trip Length From -	To Excluding	Observed Distribution	Calculated Distribution	Squared Difference	Chi - Squared Factor	F Factor Used
Zero	2.00	417	415	4.000E 00	9.592E-03	336
2.00	3.00	1,155	1,152	9.000E 00	7.792E-03	446
3.00	4.00	1,381	1,385	1.600E 01	1.159E-02	374
4.00	5.00	2,462	2,460	4.000E 00	1.625E-03	299
5.00	6.00	2,572	2,573	1.000E 00	3.888E-04	164
6.00	7.00	2,608	2,585	5.290E 02	2.028E-01	117
7.00	8.00	2,696	2,704	6.400E 01	2.374E-02	80
8.00	9.00	2,212	2,208	1.600E 01	7.233E-03	63
9.00	10.00	1,460	1,457	9.000E 00	6.164E-03	92
10.00	11.00	1,163	1,166	9.000E 00	7.739E-03	70
11.00	12.00	1,327	1,340	1.690E 02	1.274E-01	74
12.00	13.00	1,362	1,364	4.000E 00	2.937E-03	53
13.00	14.00	1,073	1,066	4.900E 01	4.567E-02	30
14.00	15.00	897	897	0.0	0.0	38
15.00	16.00	727	728	1.000E 00	1.376E-03	21
16.00	17.00	309	317	6.400E 01	2.071E-01	16
17.00	18.00	142	145	9.000E 00	6.338E-02	7
18.00	19.00	92	95	9.000E 00	9.783E-02	8
19.00	20.00	2		4.000E 00	2.000E 00	
20.00	and over	20	20	0.0	0.0	5
	TOTAL	24,077	24,077	9.700E 02	2.824E 00	

Root Mean Square Error	6.9641933
Chi - Square Probability	0.99998951
% Root Mean Square Error	0.57849324
Coefficient of Correlation	0.59368902

FIGURE VII-2

HOME BASED OTHER TRIP DISTRIBUTION

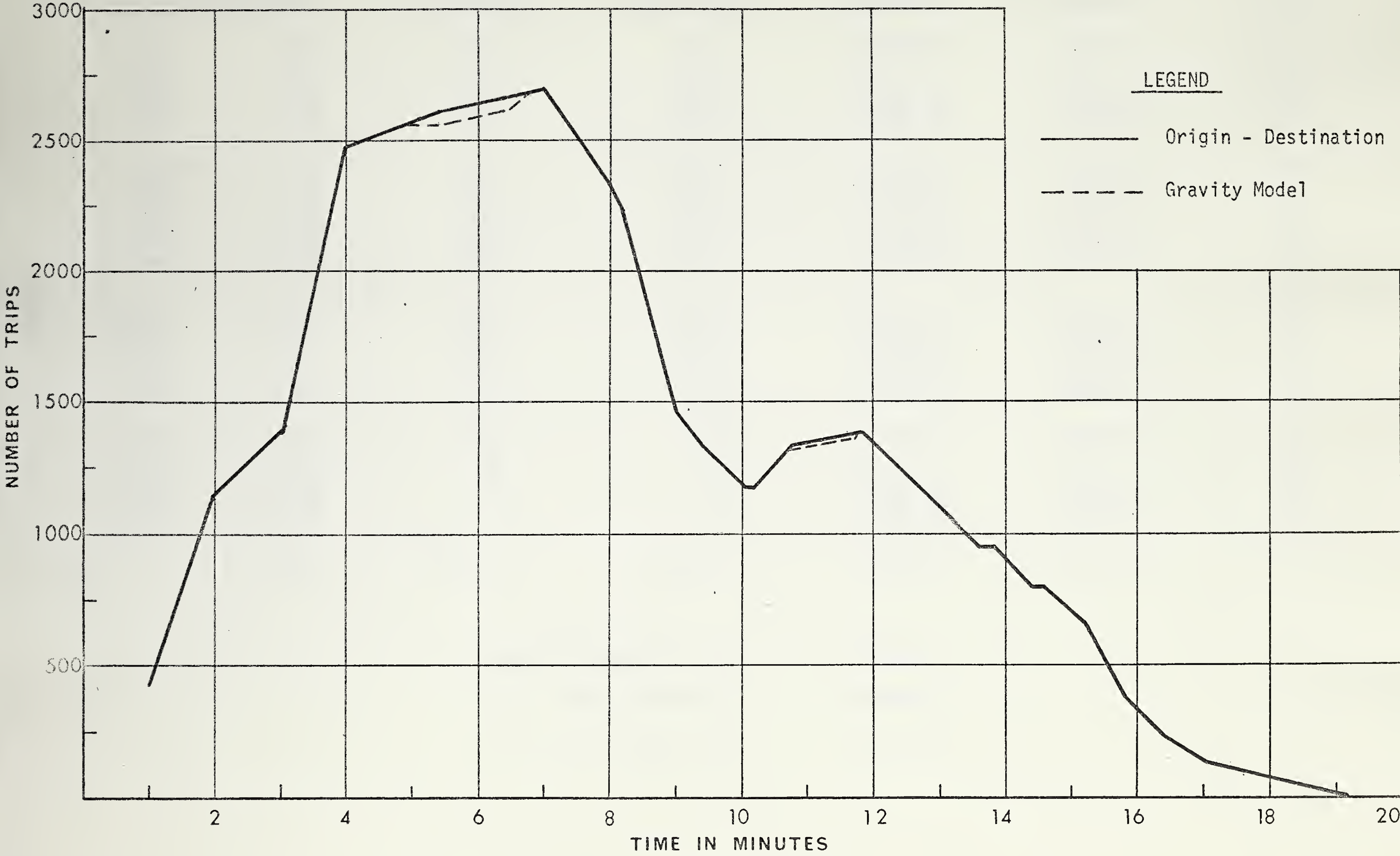


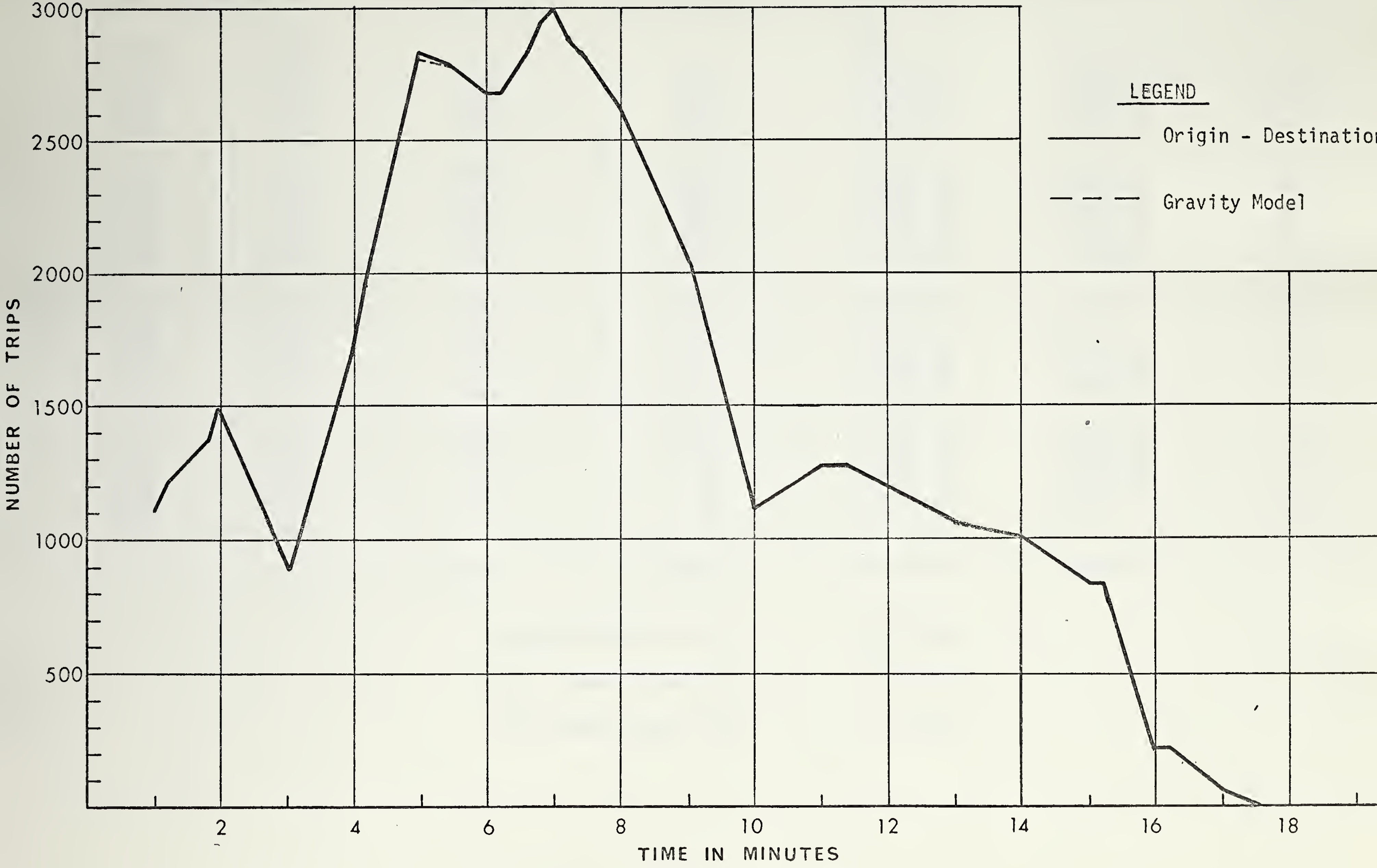
TABLE VII-3
GRAVITY MODEL CALIBRATIONS
for
Non - Home Based Trips

Trip Length From -	To Excluding	Observed Distribution	Calculated Distribution	Squared Difference	Chi - Squared Factor	F Factor Used
Zero	2.00	1,122	1,120	4.000E 00	3.565E-03	119
2.00	3.00	1,459	1,459	0.0	0.0	141
3.00	4.00	911	915	1.600E 01	1.756E-02	147
4.00	5.00	1,694	1,698	1.600E 01	9.445E-03	136
5.00	6.00	2,853	2,846	4.900E 01	1.717E-02	125
6.00	7.00	2,668	2,657	1.210E 02	4.535E-02	87
7.00	8.00	2,997	2,993	1.600E 01	5.339E-03	83
8.00	9.00	2,544	2,569	6.250E 02	2.457E-01	68
9.00	10.00	2,066	2,063	9.000E 00	4.356E-03	75
10.00	11.00	1,108	1,109	1.000E 00	9.025E-04	51
11.00	12.00	1,282	1,282	0.0	0.0	63
12.00	13.00	1,136	1,140	1.600E 01	1.408E-02	48
13.00	14.00	1,037	1,035	4.000E 00	3.857E-03	57
14.00	15.00	1,014	1,013	1.000E 00	9.862E-04	51
15.00	16.00	828	822	3.600E 01	4.348E-02	53
16.00	17.00	231	232	1.000E 00	4.329E-03	47
17.00	18.00	84	84	0.0	0.0	28
18.00	19.00	38	41	9.000E 00	2.368E-01	25
19.00	20.00	19	16	9.000E 00	4.737E-01	23
20.00	and over	9	6	9.000E 00	1.000E 00	275
	TOTAL	25,100	25,100	9.420E 02	2.127E 00	

Root Mean Square Error	6.8629427
Chi - Square Probability	0.99999714
% Root Mean Square Error	0.54684788

FIGURE VII-3

NON HOME BASED TRIP DISTRIBUTION



# TABLE VII-4
# GRAVITY MODEL CALIBRATIONS
for
Internal - External Trips

Trip Length From -	To Excluding	Observed Distribution	Calculated Distribution	Squared Difference	Chi - Squared Factor	F Factor Used
Zero	2.00			0.0	0.0	
2.00	3.00	4	2	4.000E 00	1.000E 00	2
3.00	4.00	234	241	4.900E 01	2.094E-01	458
4.00	5.00	598	603	2.500E 01	4.181E-02	846
5.00	6.00	676	687	1.210E 02	1.790E-01	685
6.00	7.00	680	678	4.000E 00	5.882E-03	397
7.00	8.00	1,811	1,850	1.521E 03	8.399E-01	94
8.00	9.00	1,612	1,608	1.600E 01	9.926E-03	362
9.00	10.00	998	982	2.560E 02	2.565E-01	370
10.00	11.00	773	772	1.000E 00	1.294E-03	372
11.00	12.00	861	860	1.000E 00	1.161E-03	129
12.00	13.00	342	342	0.0	0.0	130
13.00	14.00	356	357	1.000E 00	2.809E-03	135
14.00	15.00	492	477	2.250E 02	4.573E-01	167
15.00	16.00	396	388	6.400E 01	1.616E-01	27
16.00	17.00	251	252	1.000E 00	3.984E-03	66
17.00	18.00	184	180	1.600E 01	8.696E-02	26
18.00	19.00	64	62	4.000E 00	6.250E-02	132
19.00	20.00	64	55	8.100E 01	1.266E 00	172
20.00	and over	22	22	0.0	0.0	110
	TOTAL	10,418	10,418	2.390E 03	4.586E 00	

Root Mean Square Error	11.215590
Chi - Square Probability	0.99937361
% Root Mean Square Error	2.0454607

FIGURE VIII-4

INTERNAL - EXTERNAL TRIP DISTRIBUTION

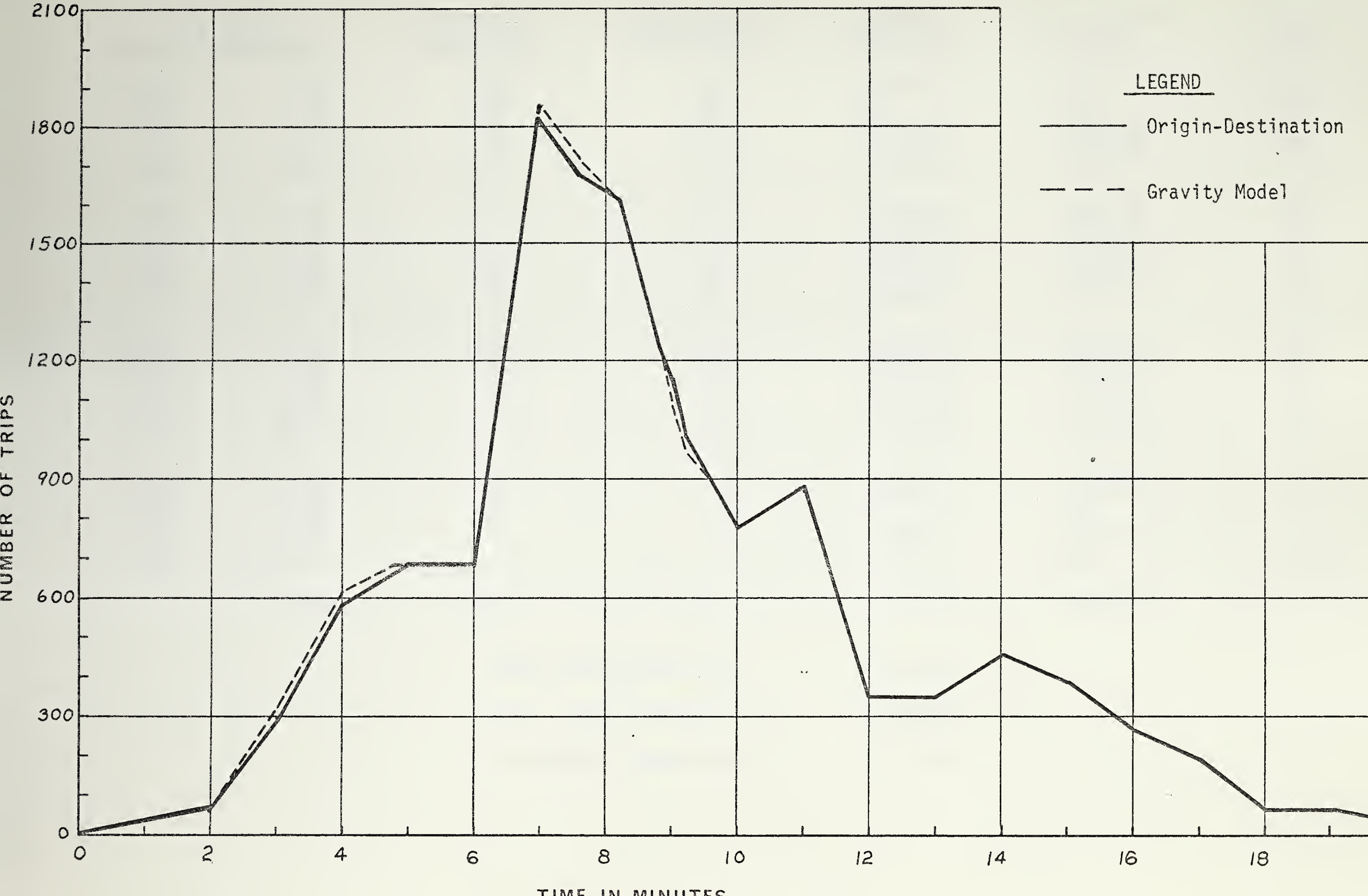


TABLE VII-5

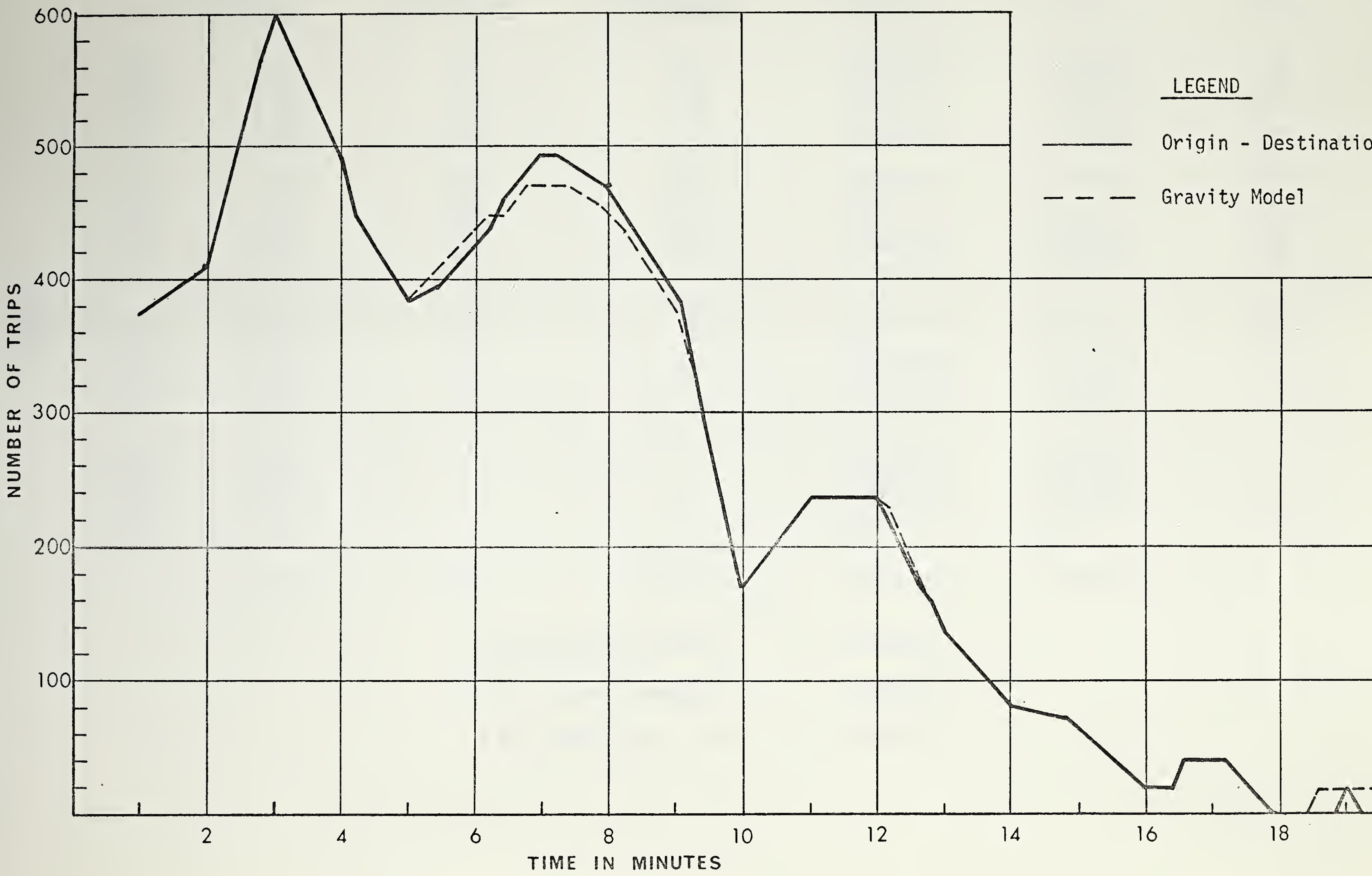
GRAVITY MODEL CALIBRATIONS for Truck Trips

Trip Length From	To Excluding	Observed Distribution	Calculated Distribution	Squared Difference	Chi - Squared Factor	F Factor Used
Zero	2.00	376	377	1.000E 00	2.660E-03	476
2.00	3.00	408	408	0.0	0.0	241
3.00	4.00	603	609	3.600E 01	5.970E-02	315
4.00	5.00	465	463	4.000E 00	8.602E-03	190
5.00	6.00	381	382	1.000E 00	2.625E-03	96
6.00	7.00	430	438	6.400E 01	1.488E-01	82
7.00	8.00	493	474	3.610E 02	7.323E-01	59
8.00	9.00	465	457	6.400E 01	1.376E-01	47
9.00	10.00	384	376	6.400E 01	1.667E-01	50
10.00	11.00	172	176	1.600E 01	9.302E-02	22
11.00	12.00	240	238	4.000E 00	1.667E-02	40
12.00	13.00	230	238	6.400E 01	2.783E-01	42
13.00	14.00	138	144	3.600E 01	2.609E-01	23
14.00	15.00	85	86	1.000E 00	1.176E-02	8
15.00	16.00	67	66	1.000E 00	1.493E-02	12
16.00	17.00	6	9	9.000E 00	1.500E 00	1
17.00	18.00	24	22	4.000E 00	1.667E-01	6
18.00	19.00			0.0	0.0	
19.00	20.00	6	10	1.600E 01	2.667E 00	1
20.00	and over			0.0	0.0	
	TOTAL	4,973	4,973	7.460E 02	6.268E 00	

Root Mean Square Error	6.4377356
Chi - Square Probability	0.98995894
% Root Mean Square Error	2.3301668

FIGURE VII-

TRUCK TRIP DISTRIBUTION



# TABLE VII-6
# GRAVITY MODEL CALCULATIONS
for
Taxi Trips

Trip Length From -	To Excluding	Observed Distribution	Calculated Distribution	Squared Difference	Chi - Squared Factor	F Factor Used
Zero	2.00	88	87	1.000E 00	1.136E-02	78
2.00	3.00	86	87	1.000E 00	1.163E-02	88
3.00	4.00	61	60	1.000E 00	1.639E-02	230
4.00	5.00	100	99	1.000E 00	1.000E-02	400
5.00	6.00	129	130	1.000E 00	7.752E-03	252
6.00	7.00	250	254	1.600E 01	6.400E-02	219
7.00	8.00	276	276	0.0	0.0	174
8.00	9.00	200	197	9.000E 00	4.500E-02	120
9.00	10.00	116	114	4.000E 00	3.448E-02	222
10.00	11.00	85	84	1.000E 00	1.176E-02	155
11.00	12.00	65	70	2.500E 01	3.846E-01	202
12.00	13.00	61	61	0.0	0.0	145
13.00	14.00	53	51	4.000E 00	7.547E-02	132
14.00	15.00	41	39	4.000E 00	9.756E-02	92
15.00	16.00	31	33	4.000E 00	1.290E-01	53
16.00	17.00	16	17	1.000E 00	6.250E-02	11
17.00	18.00	2		4.000E 00	2.000E 00	
18.00	19.00	11	8	9.000E 00	8.182E-01	348
19.00	20.00	5	9	1.600E 01	3.200E 00	63
20.00	and over			0.0	0.0	
	TOTAL	1,676	1,676	1.020E 02	6.980E 00	

Root Mean Square Error	2.3169851
Chi - Squared Probability	0.99029511
% Root Mean Square Error	2.6266518

FIGURE VII-6

TAXI TRIP DISTRIBUTION

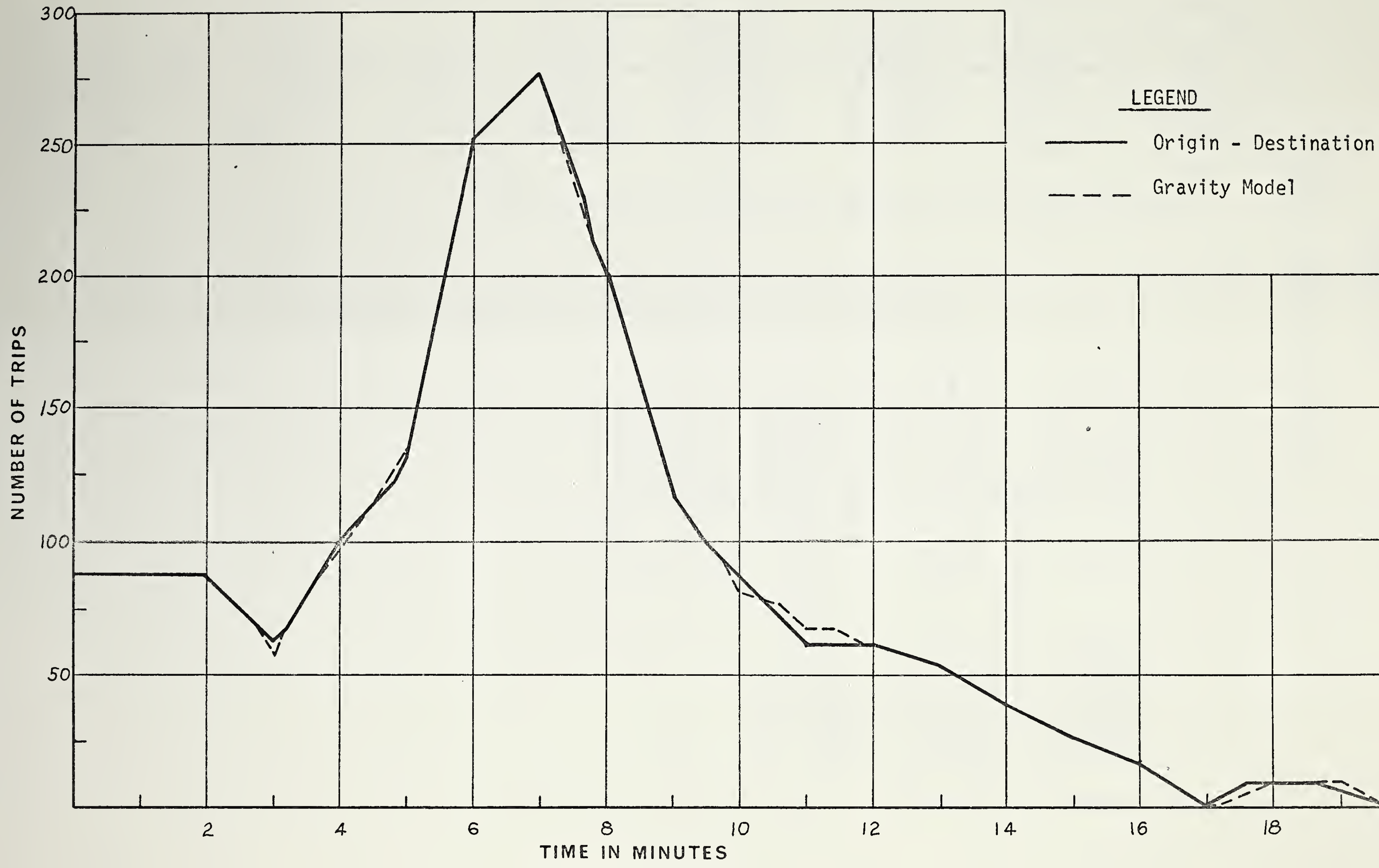
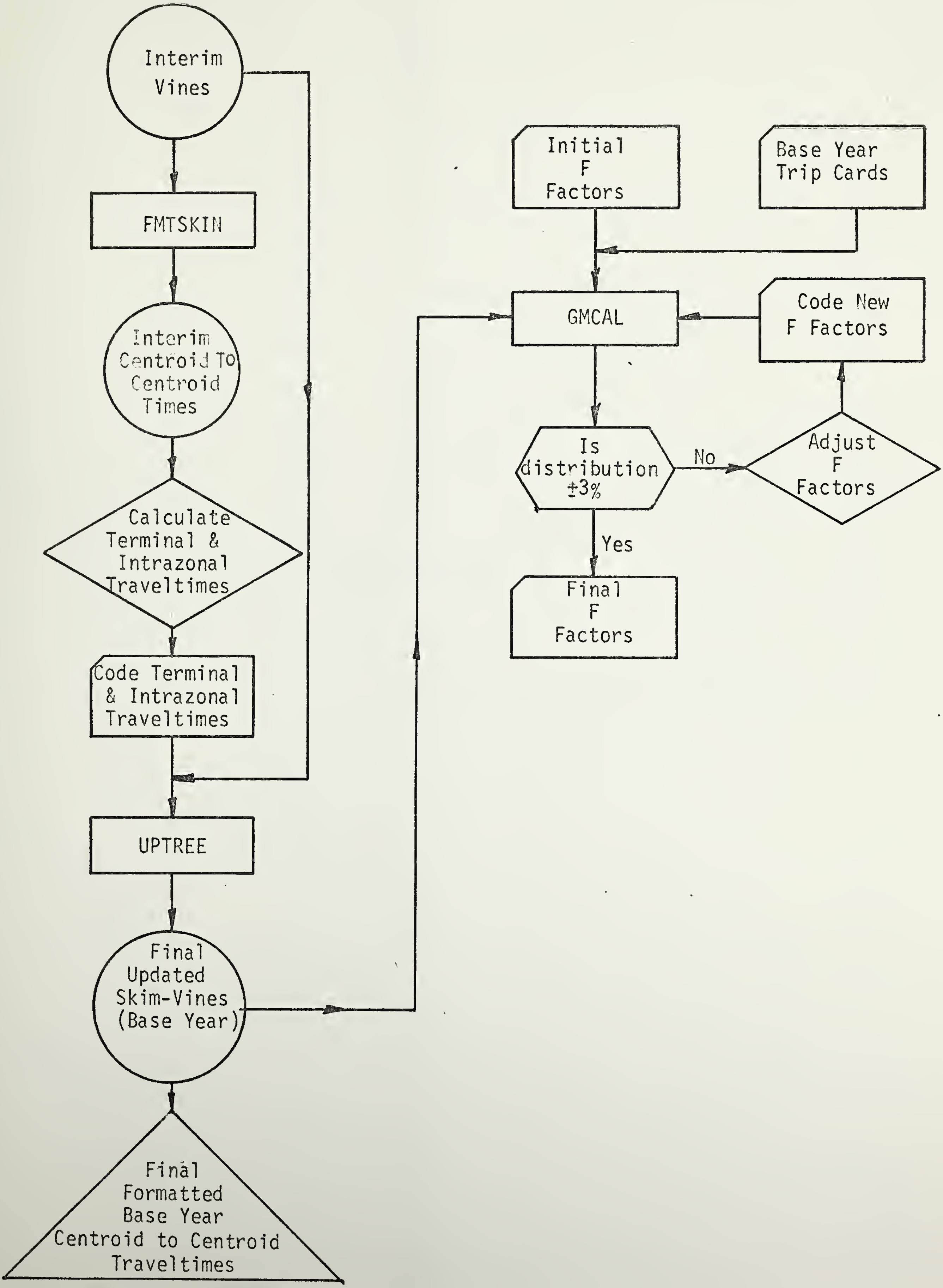


FIGURE VII-7

GRAVITY MODEL CALIBRATION


Interim Vines
FMTSKIN
Interim Centroid To Centroid Times
Calculate Terminal & Intrazonal Traveltimes
Code Terminal & Intrazonal Traveltimes
UPTREE
Final Updated Skim-Vines (Base Year)
Final Formatted Base Year Centroid to Centroid Traveltimes
Initial F Factors
Base Year Trip Cards
GMCAL
Code New F Factors
Is distribution ±3%
No
Adjust F Factors
Yes
Final F Factors

APPENDIX

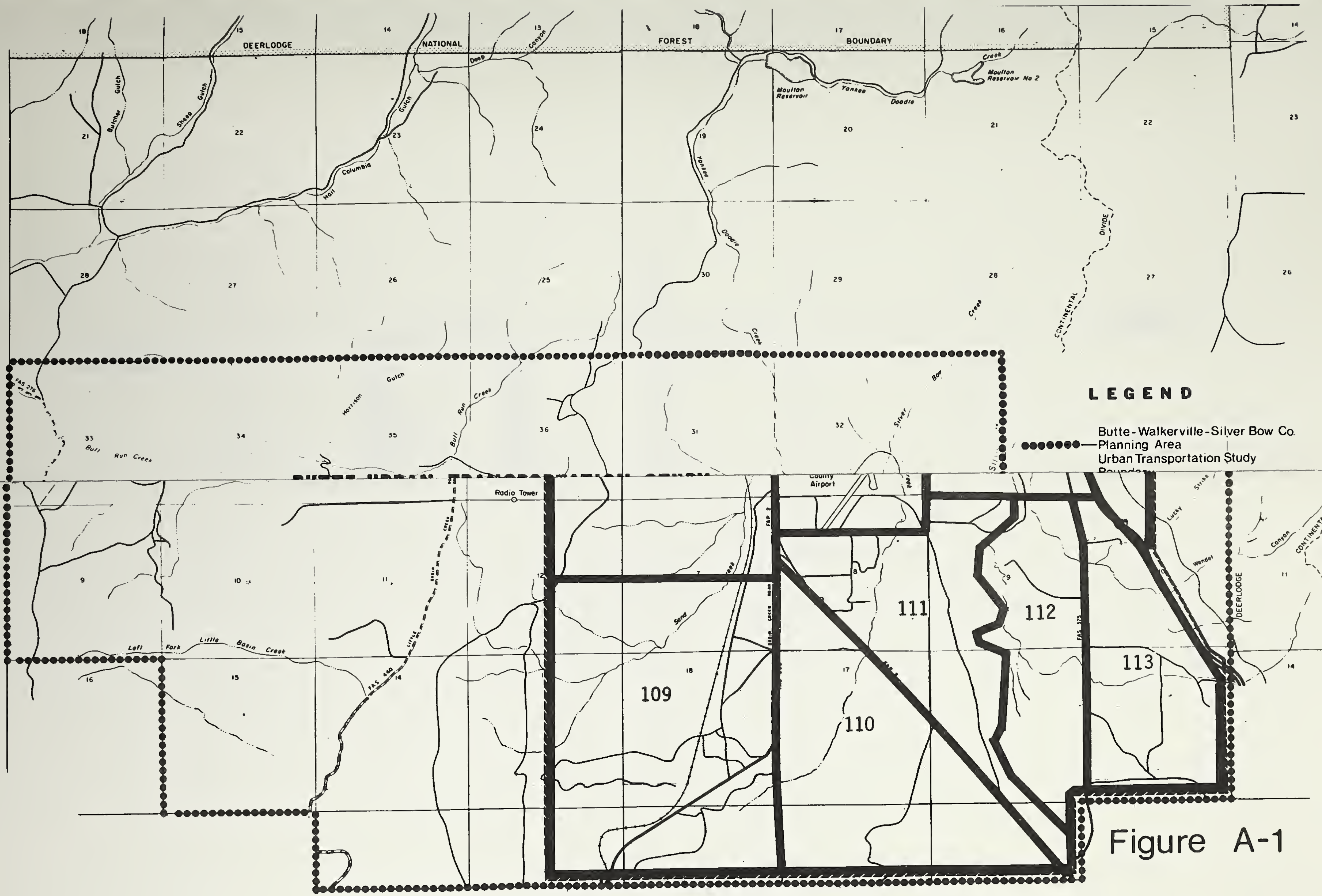


Figure A-1

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

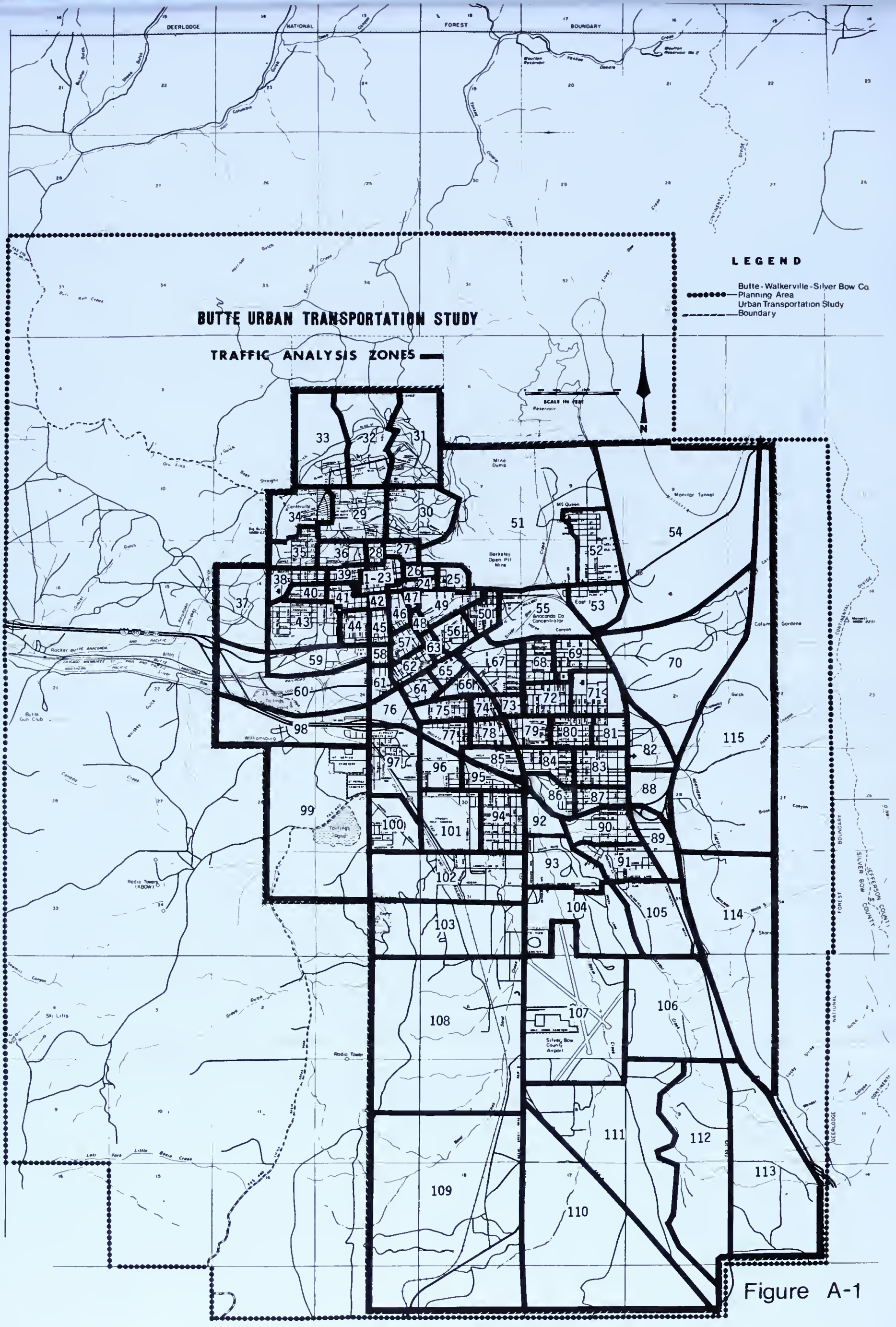
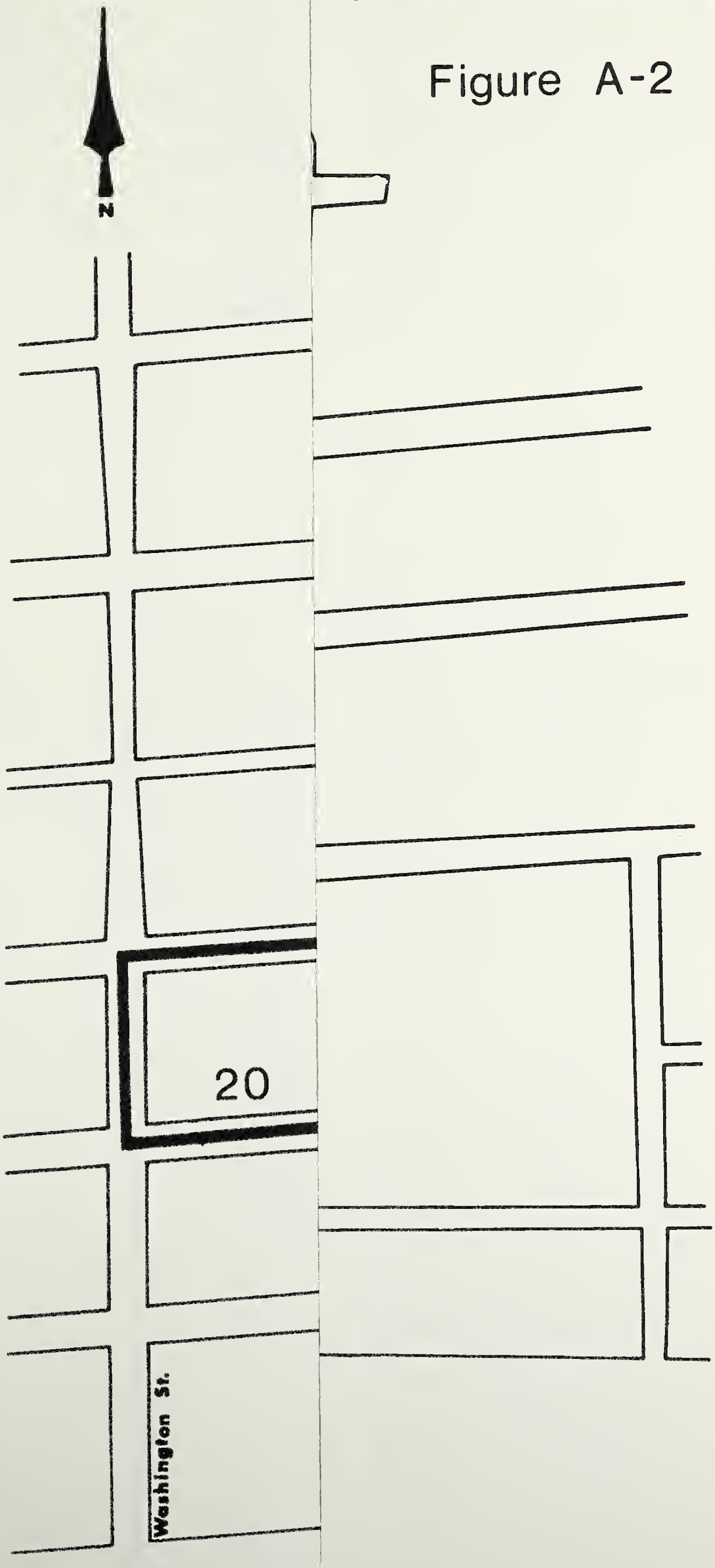


Figure A-1

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

TRAFFIC ANALYSIS ZONES

Figure A-2



BUTTE URBAN
TRANSPORTATION STUDY

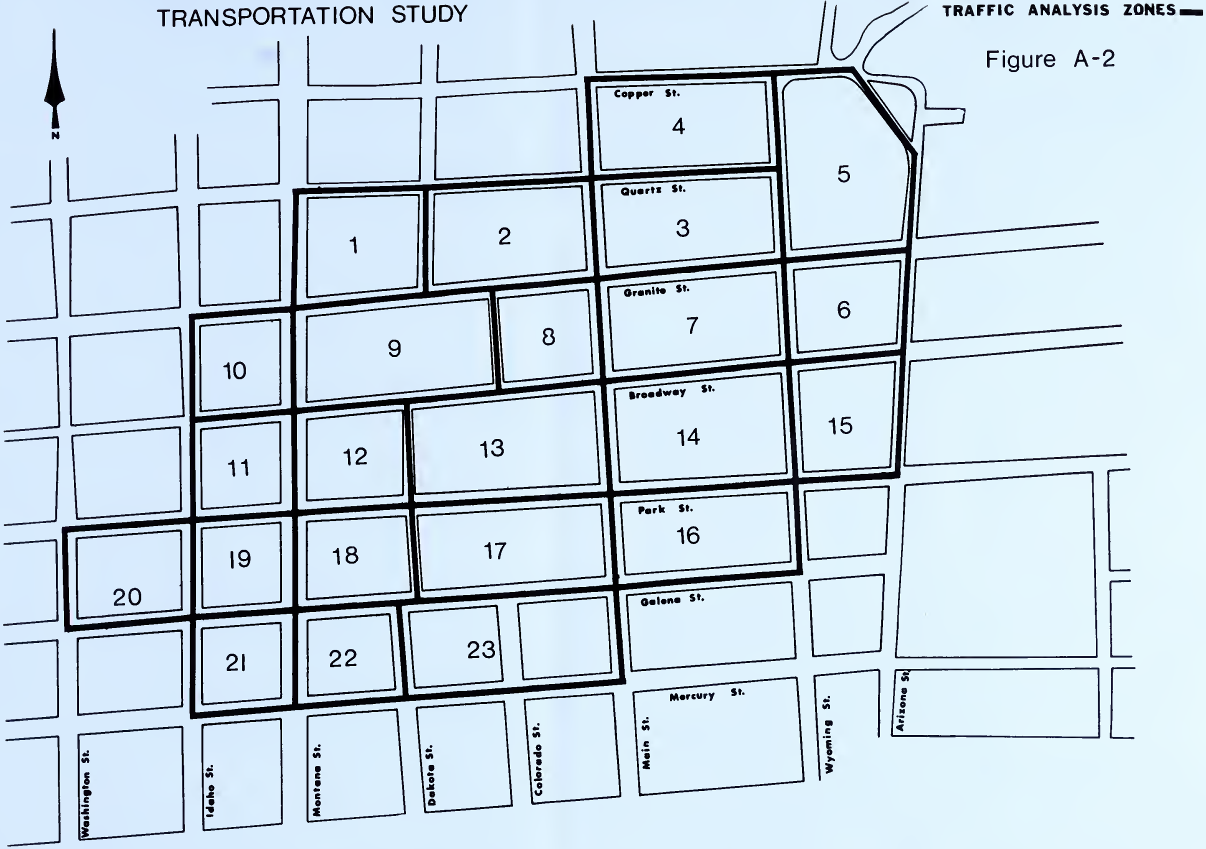


Figure A-2

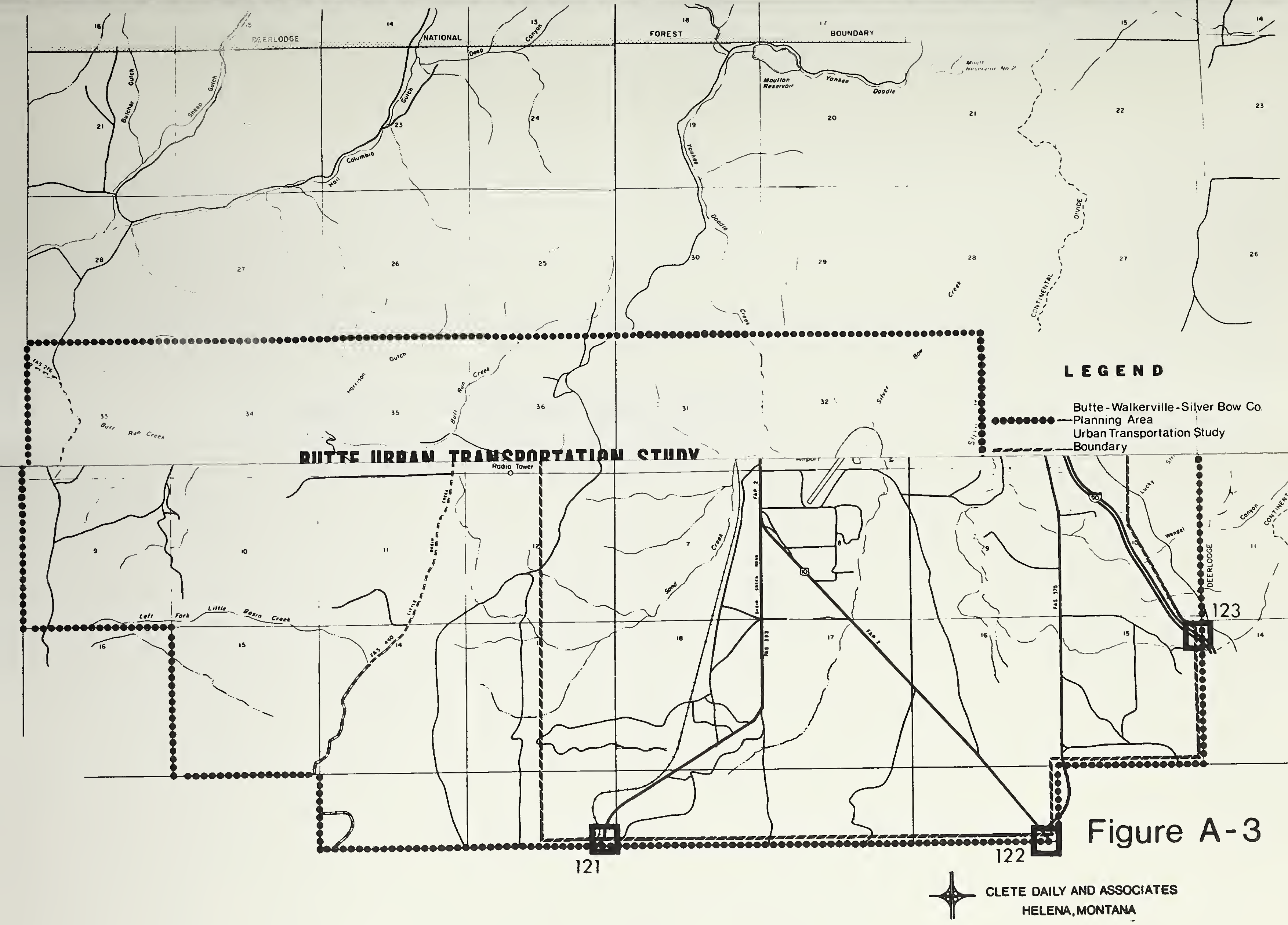

DEERLODGE NATIONAL FOREST BOUNDARY
BUTTE URBAN TRANSPORTATION STUDY
LEGEND
Butte-Walkerville-Silver Bow Co. Planning Area
Urban Transportation Study Boundary
Moulton Reservoir
Yankee Doodle
Butcher Gulch
Sheep Gulch
Hail Columbia Gulch
Deep Canyon
Bull Run Creek
Harrison Gulch
Silver Bow Creek
Sand Creek
Left Fork Little Basin Creek
Little Basin Creek
CONTINENTAL DIVIDE
Radio Tower
Airport
Lucky
Wendel
Canyon
DEERLODGE
FAP 2
FAS 375
FAS 393
FAS 440
FAS 276
Basin Creek Road
90
10
121
122
123
CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

Figure A-3

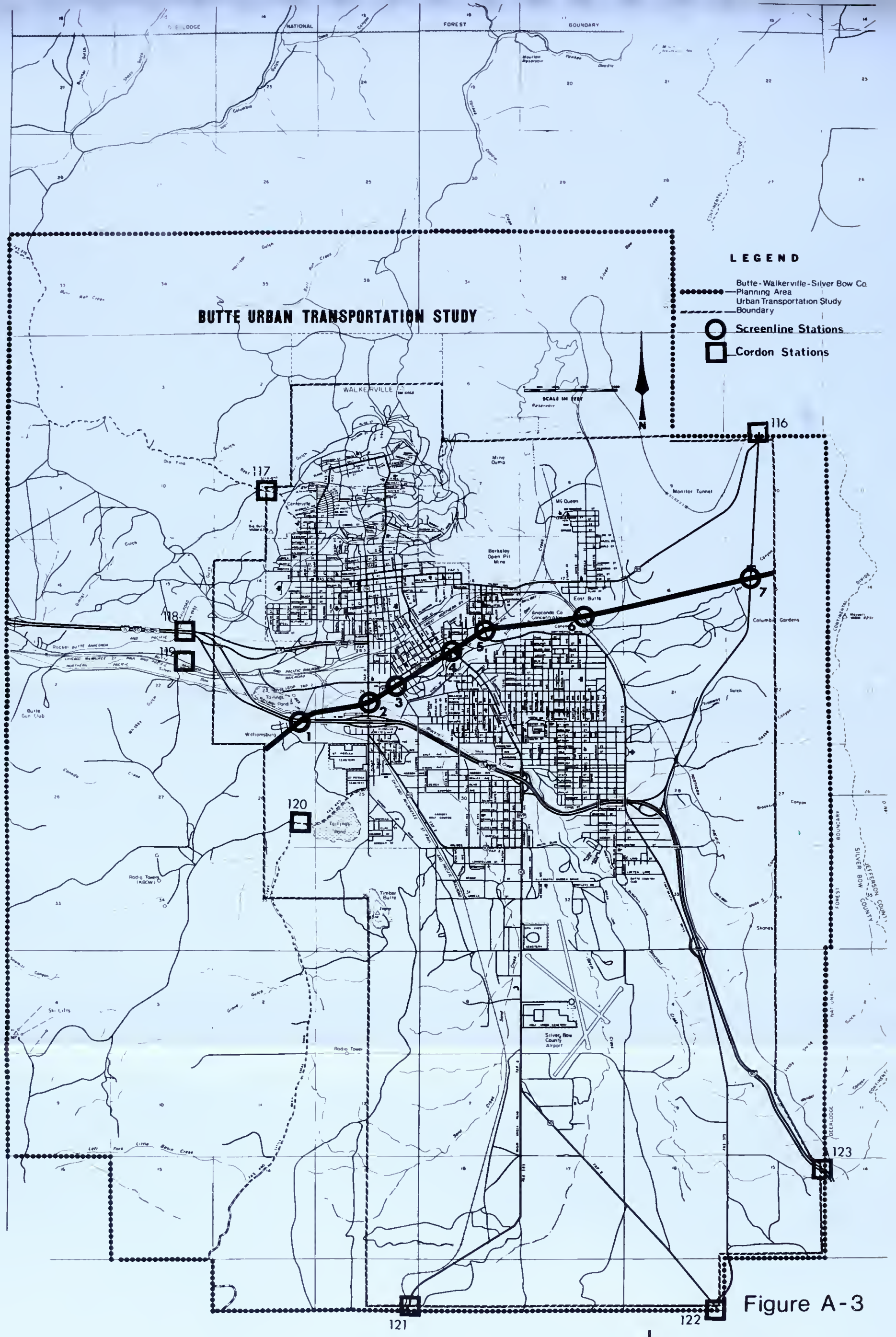


Figure A-3

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

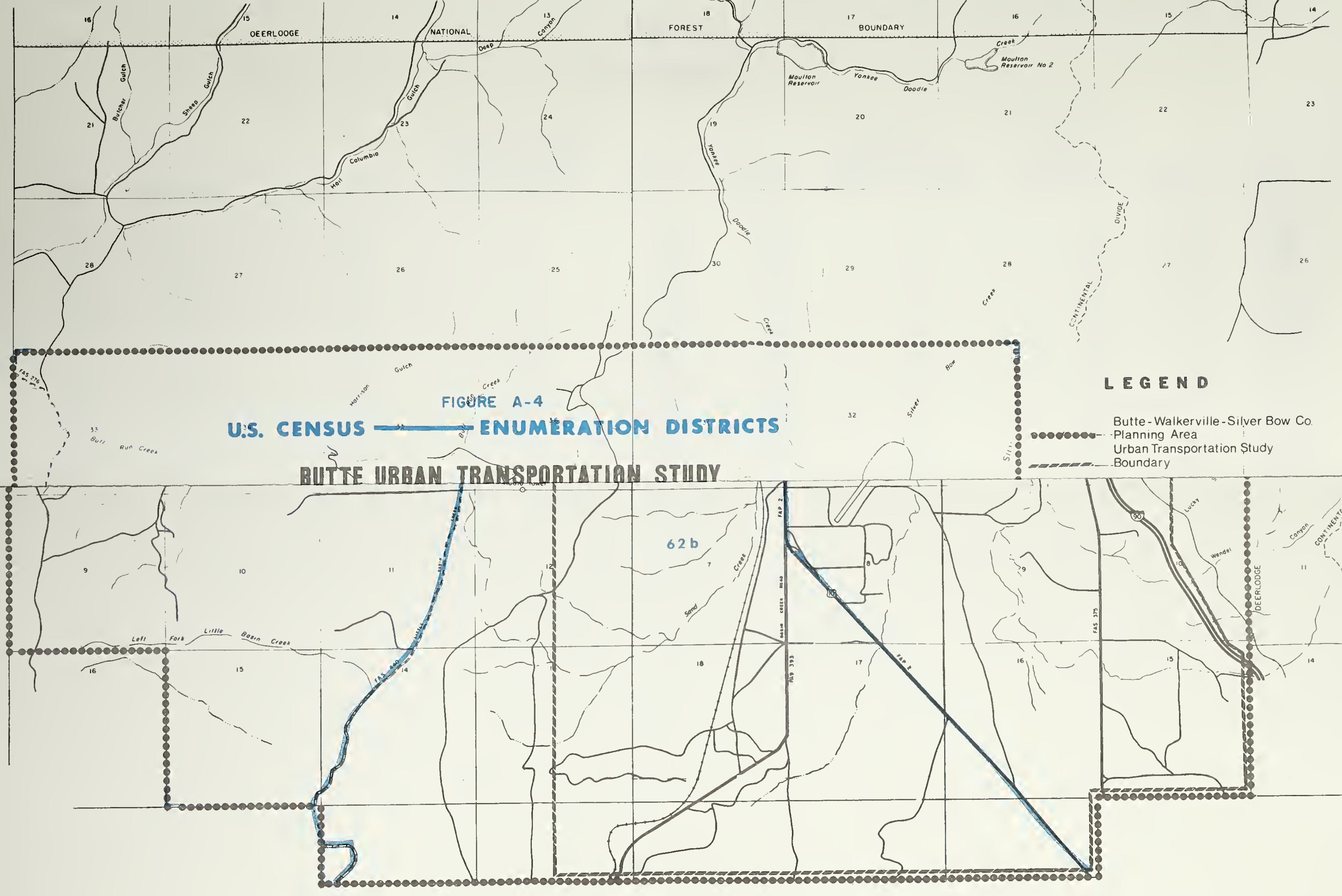


FIGURE A-4

U.S. CENSUS ——— ENUMERATION DISTRICTS

BUTTE URBAN TRANSPORTATION STUDY

L E G E N D

●●●●●●●●— Butte-Walkerville-Silver Bow Co. Planning Area

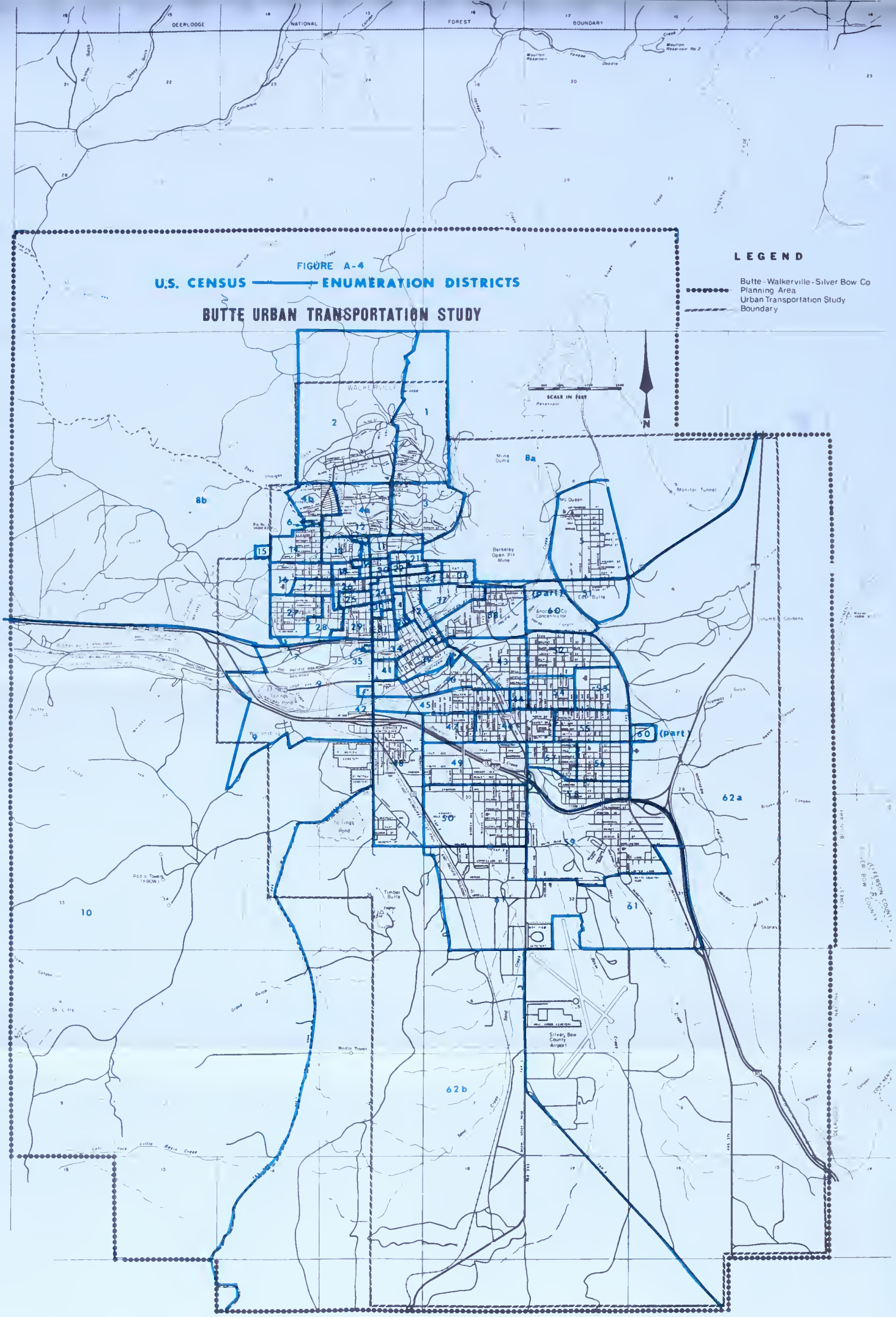
▬ ▬ ▬ ▬ — Urban Transportation Study Boundary

CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

FIGURE A-4

U.S. CENSUS —— ENUMERATION DISTRICTS

BUTTE URBAN TRANSPORTATION STUDY



CLETE DAILY AND ASSOCIATES
HELENA, MONTANA

TABLE A-1

1970 EMPLOYMENT

Zone	Residential	Manufacturing	Transportation Communication and Utilities	Trade	Services	Cultural Entertainment and Recreation	Resource Production and Extraction	Other	1970 Totals
1	0	0	0	0	201	0	5	0	206
2	0	125	0	24	84	0	0	0	233
3	0	0	0	17	0	0	0	0	17
4	0	0	0	5	0	0	0	0	5
5	17	0	0	3	0	0	12	0	32
6	0	0	0	8	5	0	0	0	13
7	2	0	0	100	37	0	43	1	183
8	6	3	0	105	169	0	0	4	287
9	0	0	97	23	68	0	0	0	188
10	0	0	0	0	4	0	0	0	4
11	0	0	138	4	9	0	0	0	151
12	0	0	0	98	60	0	0	0	158
13	0	0	0	153	72	0	0	14	239
14	0	0	287	109	391	0	0	0	787
15	110	0	0	0	7	0	0	0	117
16	0	0	0	2	5	0	0	0	7
17	16	0	3	229	275	0	0	0	523
18	0	4	0	19	31	0	0	0	54
19	0	0	0	30	29	32	0	0	91
20	0	0	0	0	0	22	0	0	22
21	0	0	0	0	0	0	0	0	0
22	0	0	0	5	9	0	0	0	14
23	0	0	0	17	41	0	0	0	58
C.B.D. Sub-Total	151	132	525	951	1,497	54	60	19	3,389
24	0	23	0	45	0	0	0	0	68
25	0	0	0	0	25	0	0	0	25
26	0	14	0	5	22	0	0	0	41
27	0	0	0	6	293	0	0	0	299
28	0	0	0	0	51	0	545	0	596
29	0	0	0	4	1	0	0	0	5
30	0	0	0	0	6	0	484	0	490

TABLE A-1 (continued)

1970 EMPLOYMENT

Zone	Residential	Manufacturing	Transportation Communication and Utilities	Trade	Services	Cultural Entertainment and Recreation	Resource Production and Extraction	Other	1970 Totals
31	0	0	0	0	0	0	0	0	0
32	0	0	0	5	19	0	0	0	24
33	0	0	0	0	0	0	0	0	0
34	0	0	0	0	15	0	0	0	15
35	0	0	0	0	78	0	0	0	78
36	0	0	0	0	14	0	0	0	14
37	0	0	0	0	0	0	0	0	0
38	0	0	0	3	313	0	0	2	318
39	4	0	0	19	26	0	0	0	49
40	0	0	0	4	2	0	0	0	6
41	0	30	0	9	182	0	0	0	221
42	3	16	0	10	66	0	0	3	98
43	0	3	0	17	637	0	3	2	662
44	0	0	0	14	19	0	0	0	33
45	2	0	0	29	23	0	7	0	61
46	0	10	3	44	242	0	0	0	299
47	0	0	0	0	0	0	0	0	0
48	0	0	0	141	43	0	0	0	184
49	0	0	0	12	50	0	0	0	62
50	0	0	0	7	0	0	0	0	7
51	0	0	0	0	0	0	2,207	0	2,207
52	0	0	0	0	10	1	0	0	11
53	0	0	0	9	0	0	0	0	9
54	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	135	0	135
56	0	38	0	16	12	0	0	0	66
57	2	25	0	42	53	0	0	0	122
58	4	0	0	16	27	0	0	0	47
59	0	0	0	13	20	0	0	0	33
60	3	2	59	54	26	4	0	0	148
61	0	3	39	101	28	0	0	0	171
62	3	13	48	126	31	0	3	0	224
63	3	11	0	32	22	0	0	0	68
64	0	0	0	0	6	0	0	0	6

TABLE A-1 (continued)

1970 EMPLOYMENT

Zone	Residential	Manufacturing	Transportation Communication and Utilities	Trade	Services	Cultural Entertainment and Recreation	Resource Production and Extraction	Other	1970 Totals
65	0	0	0	73	169	0	0	0	242
66	0	0	0	17	3	0	0	0	20
67	0	0	0	29	114	0	0	0	143
68	0	0	0	12	12	4	0	0	28
69	0	14	0	7	23	0	0	0	44
70	0	0	0	3	0	0	0	0	3
71	0	0	0	9	87	2	0	0	98
72	0	2	0	11	6	0	0	0	19
73	0	8	0	54	0	0	0	0	62
74	3	10	0	38	76	0	0	0	127
75	0	0	0	3	0	0	0	0	3
76	0	13	0	37	0	0	0	0	50
77	0	0	0	1	8	0	0	0	9
78	0	0	0	38	22	0	0	0	60
79	0	0	0	112	37	0	0	0	149
80	0	0	0	0	71	0	0	0	71
81	0	0	0	0	24	0	2	0	26
82	0	0	0	0	298	0	0	0	298
83	0	14	0	9	111	2	0	0	136
84	0	0	0	28	29	0	0	0	57
85	0	0	0	30	4	0	0	0	34
86	0	0	0	39	0	0	0	0	39
87	2	0	0	0	24	0	0	2	28
88	0	0	0	0	56	0	0	0	56
89	0	0	0	0	0	0	0	0	0
90	0	0	0	0	3	0	0	0	3
91	0	0	0	0	20	0	0	0	20
92	6	0	0	93	30	0	0	18	147
93	4	0	0	110	1	0	0	0	115
94	14	0	0	78	59	0	0	0	151
95	0	0	0	5	0	0	0	0	5
96	0	0	18	0	0	0	0	0	18
97	0	2	0	6	37	0	0	0	45
98	0	43	0	12	32	0	0	0	87

TABLE A-1 (continued)

1970 EMPLOYMENT

Zone	Residential	Manufacturing	Transportation Communication and Utilities	Trade	Services	Cultural Entertainment and Recreation	Resource Production and Extraction	Other	1970 Totals
99	0	0	0	0	4	0	0	0	4
100	0	0	0	0	53	0	0	0	53
101	0	0	0	78	2	7	0	0	87
102	17	41	0	8	295	0	0	0	361
103	0	0	0	13	119	0	0	0	132
104	0	0	0	0	3	0	0	0	3
105	0	0	0	5	12	13	0	0	30
106	0	0	0	0	0	0	0	0	0
107	0	0	0	5	76	0	0	0	81
108	0	0	0	1	33	1	15	0	50
109	0	0	0	0	3	0	0	0	3
110	0	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0
113	0	0	0	0	0	0	0	0	0
114	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	0
Total	221	467	692	2,698	5,815	88	3,461	46	13,488

TABLE A-2

1970 TRIP GENERATION VARIABLES

Zone	Total Dwelling Units (occupied + vacant)			Population	No. of Persons 5 & over	Employees	Employment	Vehicles (Cars + Pickups)	No. of Trucks	Floor* Space (sq. ft.)
	Single Family	Multi-Family	Total							
1	0	26	26	17	17	0	206	0	0	135,900
2	0	0	0	0	0	0	233	0	6	93,763
3	0	63	63	61	61	13	17	11	3	42,840
4	0	0	0	0	0	0	5	0	0	16,710
5	0	48	48	18	18	6	32	6	0	25,569
6	0	82	82	15	15	66	13	33	0	36,404
7	0	131	131	82	82	16	183	16	0	315,387
8	0	37	37	33	33	19	287	14	0	106,486
9	0	61	61	93	84	23	188	33	3	65,685
10	7	43	50	36	36	0	4	0	0	58,504
11	0	43	43	43	43	17	151	7	0	66,093
12	0	23	23	23	23	0	158	0	3	92,967
13	0	113	113	65	65	16	239	0	3	165,087
14	0	36	36	36	36	0	787	0	6	319,721
15	3	22	25	16	16	6	117	6	0	25,078
16	0	47	47	47	47	47	7	94	0	105,842
17	0	139	139	120	120	32	523	25	0	200,855
18	0	0	0	0	0	0	54	0	9	62,524
19	0	6	6	6	6	6	91	0	0	82,476
20	0	0	0	0	0	0	22	0	0	106,750
21	0	10	10	10	10	0	0	0	0	51,660
22	0	26	26	26	26	0	14	16	0	25,600
23	3	32	35	45	42	16	58	13	0	49,333
C.B.D. Sub-Total	13	988	1,001	792	780	283	3,389	274	33	2,251,234
24	62	16	78	39	39	15	68	23	0	115,925
25	19	9	28	28	28	9	25	19	0	24,983
26	97	56	153	459	417	97	41	125	0	116,318
27	105	12	117	287	254	77	299	77	0	60,939
28	45	38	83	207	194	58	596	78	30	4,200
29	161	6	167	467	435	144	5	184	9	16,050
30	184	12	196	477	420	114	490	155	9	78,294
31	160	34	194	513	422	137	0	205	3	12,180
32	131	5	136	281	258	91	24	95	12	32,072

TABLE A-2 (continued)

1970 TRIP GENERATION VARIABLES

Zone	Total Dwelling Units (occupied + vacant)			Population	No. of Persons 5 & over	Employees	Employment	Vehicles (Cars + Pickups)	No. of Trucks	Floor* Space (sq. ft.)
	Single Family	Multi-Family	Total							
33	88	5	93	228	209	84	0	121	3	20,598
34	185	20	205	535	505	195	15	220	0	396,555
35	348	22	370	1,208	1,146	376	78	513	6	87,500
36	181	48	229	579	572	192	14	255	0	24,700
37	0	0	0	0	0	0	0	0	0	3,200
38	122	107	229	618	589	168	318	235	9	361,342
39	314	335	649	1,327	1,216	415	49	507	6	140,409
40	170	50	220	710	645	195	6	315	6	4,600
41	289	304	593	1,135	1,072	374	221	515	9	162,650
42	66	66	132	155	144	33	98	55	13	48,775
43	396	83	479	1,367	1,244	437	662	643	18	276,950
44	215	158	373	980	870	287	33	430	9	28,231
45	224	182	406	950	877	240	61	339	6	44,570
46	113	38	151	287	257	53	299	91	6	127,452
47	48	207	255	452	356	43	0	72	6	11,100
48	5	0	5	20	10	5	184	5	24	312,496
49	38	6	44	31	31	25	62	19	27	235,345
50	15	0	15	40	40	20	7	20	18	50,326
51	0	0	0	0	0	0	2,207	0	9	0
52	282	15	297	952	769	314	11	424	3	43,450
53	5	5	10	10	10	5	9	5	0	10,675
54	5	20	25	5	5	5	0	5	0	0
55	0	0	0	0	0	0	135	0	6	2,850
56	153	19	172	423	387	131	67	144	24	121,430
57	199	96	295	576	521	123	122	192	27	210,591
58	114	36	150	342	330	96	47	168	3	34,176
59	86	0	86	201	186	43	33	100	12	93,980
60	12	0	12	24	24	12	148	18	21	215,525
61	100	0	100	180	160	73	171	120	30	108,693
62	232	79	311	771	714	227	224	329	48	133,642
63	60	21	81	153	153	55	68	77	12	86,355
64	59	5	64	212	177	64	6	89	4	1,056
65	6	3	9	18	18	3	242	9	36	1,143,712
66	162	6	168	518	485	162	20	206	6	31,547
67	344	76	420	1,068	959	353	143	534	12	125,336

TABLE A-2 (continued)

1970 TRIP GENERATION VARIABLES

	Total Dwelling Units (occupied + vacant)									
Zone	Single Family	Multi-Family	Total	Population	No. of Persons 5 & over	Employees	Employment	Vehicles (Cars + Pickups)	No. of Trucks	Floor* Space (sq. ft.)
68	278	18	296	1,016	910	311	28	433	3	9,870
69	300	11	311	1,024	914	326	44	478	15	76,119
70	56	8	64	125	125	88	3	136	6	11,200
71	196	6	202	650	536	196	98	297	6	140,159
72	381	11	392	1,254	1,169	439	19	630	12	10,194
73	140	5	145	429	414	166	62	238	3	27,564
74	170	10	180	543	527	202	127	269	3	90,154
75	155	10	165	417	379	107	3	192	12	7,209
76	0	5	5	20	10	5	50	5	3	44,700
77	183	0	183	533	518	167	9	293	3	14,900
78	328	14	342	1,159	1,068	412	60	537	3	83,730
79	272	11	283	811	751	272	149	392	9	49,396
80	281	11	292	1,057	998	287	71	446	6	82,653
81	163	5	168	593	567	200	26	326	3	1,800
82	80	5	85	275	250	85	298	160	6	75,180
83	363	6	369	1,163	1,029	369	136	609	26	825,902
84	345	6	351	1,131	976	345	57	553	15	45,137
85	104	0	104	234	229	104	34	151	4	10,206
86	63	12	75	193	188	57	39	97	0	22,083
87	182	0	182	607	532	173	28	262	3	5,300
88	0	0	0	0	0	0	56	0	0	9,960
89	52	0	52	189	163	78	0	117	0	0
90	295	0	295	1,133	1,080	362	3	581	9	4,458
91	205	0	205	701	650	211	20	348	17	22,060
92	70	0	70	233	210	47	147	93	0	126,582
93	42	0	42	93	93	23	115	42	6	20,952
94	295	15	310	984	891	300	151	477	9	91,589
95	151	6	157	457	416	127	5	220	9	2,038
96	112	0	112	398	367	143	18	193	6	6,000
97	153	30	183	513	496	157	45	248	12	57,328
98	77	0	77	217	182	49	86	119	20	0
99	10	5	15	65	65	20	4	30	3	0
100	72	0	72	206	206	72	53	123	0	93,400
101	96	0	96	237	205	90	87	134	9	17,542
102	106	0	106	255	240	128	361	158	30	67,135

TABLE A-2 (continued)

1970 TRIP GENERATION VARIABLES

Zone	Total Dwelling Units (occupied + vacant) Single Family	Multi-Family	Total	Population	No. of Persons 5 & over	Employees	Employment	Vehicles (Cars + Pickups)	No. of Trucks	Floor* Space (sq. ft.)
103	10	0	10	25	25	20	132	15	45	432,056
104	79	0	79	221	221	63	3	126	3	10,930
105	56	0	56	235	224	56	30	112	6	41,140
106	5	0	5	30	25	5	0	15	0	0
107	18	0	18	42	36	18	81	18	3	0
108	48	12	60	132	114	66	50	102	21	0
109	0	0	0	0	0	0	3	0	0	0
110	30	0	30	108	96	36	0	60	15	0
111	5	0	5	25	25	10	0	20	0	0
112	15	0	15	75	60	30	0	40	0	0
113	0	0	0	0	0	0	0	0	3	0
114	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	0	0	0	6	0
Total	11,655	3,410	15,065	39,433	36,108	12,255	13,488	17,905	888	10,098,638

* Floor Space includes Land Use Categories #2 through #7